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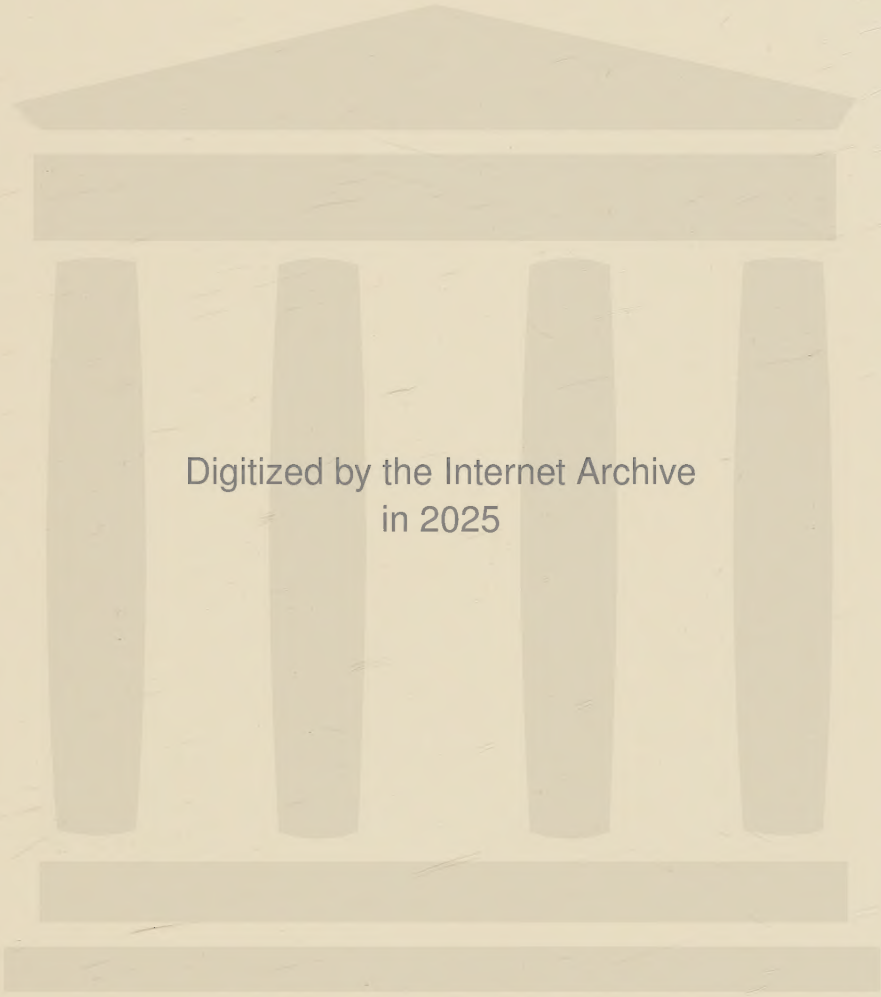
EDITORIAL

A FRUIT INDUSTRY FOR THE GOLD COAST

SOUTH African fruit experts have recently been seriously discussing the possibility of disposing of large quantities of oranges and grape fruits on the markets of India and Ceylon. One member of the South African fruit industry expresses himself certain that India and Ceylon can take all the oranges that South Africa is able to produce. It is a very anomalous position that India produces and could produce to an enormously increased extent the finest flavoured oranges obtainable anywhere in the world. These are the loose skinned "Santara" of Central India, an orange of most attractive appearance and flavour. Owing to its peculiar loose skin, for when ripe the fruit inside can almost be shaken free from the rind without opening the latter, this orange does not travel well for long distances. The brother of a recent distinguished Viceroy, a commercial man of eminence, tried to convey this orange to Europe feeling sure of its commercial possibilities there but was unable to do so in a marketable condition. It would be quite possible however with a little organisation to put this fruit profitably and in enormous quantity and good condition upon the markets in the Indian towns so that no South African fruit could compete with it. The organisation is at present what is lacking. Besides the "Santara" India produces many other good oranges. The dryness of the atmosphere in India is a great asset in the production of colour and flavour in the orange. The atmospheric humidity on the other hand is the cause of the frequently permanent green skin and lack of flavour in the oranges produced in most parts of Ceylon. Whilst the grape

fruit does not flourish well in India many regions in Ceylon are peculiarly suited to certain good varieties of this fruit. The best oranges of Central India are produced where the annual rainfall is some 45 inches. Grape fruit prefers a higher rainfall, not less than 50 inches, a condition found in Ceylon. If a market for grape fruit exists in India it ought to be possible for Ceylon to develop it rather than South Africa. A good market too for Ceylon grape fruit might be found with the boats that put into Colombo. Californian or other grape fruit that is put upon the boats in England has reached the time when replenishment with fresh fruit in Colombo would certainly be entertained if a good local fruit were obtainable. Australian and Far Eastern boats both on the outward and homeward voyage could advantageously replenish at Colombo. There should be our own home market in the Island itself for the fruit, whilst markets further away, including perhaps even Southern Europe, might be possible fields. A canning industry too might not be forgotten. Several varieties of grape fruit have been proved as suitable for cultivation in Ceylon, Marsh's Seedless grafted upon lime or sour orange stock has demonstrated itself as a satisfactory kind. Seedling trees are generally not worth growing. We print in this number an extract from a paper upon a Fruit Industry for the Gold Coast read by Mr. G. H. Eady of the Department of Agriculture, Gold Coast, before the Second Conference of West African Agricultural Officers which contains much up-to-date information upon grape fruit and lemons. It is prefixed by his remarks upon the Gold Coast climate which show it in some respects to approximate to that of Ceylon.



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Cypripedium insigne Wall.

CYPRIPEDIUM INSIGNE

LADY'S SLIPPER ORCHID OR SHOE OF VENUS

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Cypripedium insigne Wall. of the Himalayas, belongs to a race of handsome terrestrial orchids found widely distributed in both hemispheres. The plant has branching fibrous roots and a short stem bearing a cluster of leaves clasping it at the base. The flowers are very peculiar with two large brown-mottled or streaked sepals and a pair of narrow petals in the midst of which projects a slipper-like pouch or bag with inturned edge (the labellum).

On account of its easy culture, beautiful foliage, and flowers, the genus *Cypripedium* is well worthy of a position in the greenhouse. The foliage of several species of the genus is beautifully mottled and make the plants very handsome ornamental specimens even when out of bloom.

Cypripediums being terrestrial, with a few exceptions, do well in a compost made up of the following:

1 part turfy soil
1 ,, leaf mould
½ ,, finely broken limestone or (coarse sand)
½ ,, well-decomposed cattle manure.

It is not necessary that perforated pots should be used for potting Cypripediums as for most epiphytic orchids, but it is very important that the drainage should be good as these are very susceptible to the effects of bad drainage which causes damping off of the foliage. The pot should at least for one-fourth of its depth be arranged with clean broken crocks, over which a few dry leaves or *Sphagnum* moss should be placed to prevent the drainage being choked by the soil.

When potting the plant, care should be taken to see that the roots are well spread over the soil and that the base of the stem is about an inch below the rim of the pot. This space may be filled with a layer of *Sphagnum* moss so as to maintain the plant in moist condition during the early stage of growth. After potting, the plants need watering sparingly during the first few weeks till the fresh growth appears. When the plant is in active growth more water will be necessary.

Propagation could readily be effected by the division of the plant. A good well-established plant is capable of as many as half a dozen divisions but it would not be advisable to make such divisions too small so as to consist of only single plants as these will be too weak to obtain a healthy start in life. Cypripediums are more or less suited to the higher altitudes of Ceylon but with a little care and attention they can be cultivaed to perfection even at lower elevations.

BUDDING IN THE FIELD AT PERADENIYA

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THE STATE OF GROWTH OF THE STOCK

THE quarterly journal of the Rubber Research Institute of Malaya, Vol. 1, Nos. 1 and 2, contains an article by C. E. T. Mann entitled *Budding in the Field.* The author examines the effects of various factors on the percentage of successes obtained.

Mann's figures show that the highest percentage of successes was obtained in the group of stocks which were in a state of vigorous growth both at budding and at the time of opening the binding, while the lowest percentage was obtained in the group of stocks which were dormant at both these times. The latter figure (40%) is considerably lower than the percentage obtained in the next best class, but the differences between the other classes are not striking *e.g.* 72% successes were obtained with stocks that were dormant at budding but vigorous at opening against 73% with stocks that were vigorous on both occasions, while 63% successes were obtained with stocks that were vigorous at budding but dormant at opening.

Naturally the periods of activity and dormancy will not exactly synchronise in any large number of stocks and when budding starts the stocks will be at all stages, varying from full activity to complete dormancy.

It must now be considered to what practical use any conclusions drawn from Mann's investigation of this particular factor can be put. It is fairly easy to say which plants are in a state of active growth at any one time but it is thought to be hardly practicable to judge at the time of budding which stocks are likely to remain in a state of activity throughout the period between budding and opening. Even if this were possible, to select for budding only those stocks which are just entering on a period of vigorous growth would entail a large number of rounds of budding and a great expenditure of time and labour, and this procedure hardly apppears to be a practical proposition for large scale field work. Even to bud at one time only plants in a state of active growth would entail certainly three rounds of budding and would complicate affairs and add considerably to the expense.

During July, August, and September 1930, clones of 26 Ceylon mother trees were established for testing purposes on the Iriyagama Division of the Experiment Station, Peradeniya. These clones were divided among three areas in each of which plots of Heneratgoda No. 2 tree appear as a standard of comparison, while in area 3 plots of mixed seedlings are also included. Areas 1 and 2 thus each contain 9 clones + H2, while area 3 contains 8 clones + H2 and seedlings. The budding for area 2 was all done on one-year-old seedling stocks in the nursery, while in areas 1 and 3 budding was done in the field, additional nursery stocks being budded to fill vacancies and to replace failures. Area 1 was planted in 1928 with two-year-old stumps. Vacancies for which additional stumps were not available were filled with 1928 and 1929 seedlings. It will thus be seen that the stocks in this area show considerable variation. Area 3 was planted in the north-east monsoon of 1928 with 1928 seedling basket plants. The growth of stocks in this area is considerably more vigorous and more even than that of the stocks in area 1.

During the budding in areas 1 and 3 the state of growth of each stock at the time of budding was recorded. The state of the stocks at the time of the first and second inspections was also recorded, but for reasons given above the latter records are not included in this account.

The results in areas 1 and 3 are given in tables 1 and 2.

Table I

Results of budding in the field on stumps planted in 1928 or seedling supplies planted in 1928 or 1929 in area 1 of the Iriyagama Division.

Clone	Number of stocks budded	Percentage success on stocks growing vigorously	Percentage success on dormant stocks	Percentage success on all stocks
Wawulugala 120	60	86·6	80·0	85·0
H 2	56	65·4	76·7	71·4
Nakiadeniya 10	59	92·5	79·00	88·1
Eladuwa 1	57	61·0	61·9	61·4
Yogama 21 Y	59	86·3	93·3	88·1
Govinna 1836	58	60·0	58·1	58·6
Mirishena 2	60	40·0	50·0	45·0
Mirishena 11	56	23·5	13·6	19·4
H 411	59	47·6	52·6	50·8
Cuilcagh 5	59	80·0	85·2	83·0
Total	583	—	—	—
Average	58	64·3	65·3	65·0

Table II

Results of budding in the field on 1928 seedlings planted out as basket plants in October-November, 1928, in area 3 of the Iriyagama Division.

Clone	Number of stocks budded	Percentage success on stocks growing vigorously	Percentage success on dormant stocks	Percentage success on all stocks
H 2	101	59·6	34·7	47·5
H 401	108	96·0	91·3	93·5
H 439	106	85·9	92·8	88·6
Hillcroft 34	109	74·3	74·3	74·3
Milleniya 162	111	59·0	64·4	61·2
Udapola 24	102	65·6	73·7	68·6
H 47	108	56·7	50·0	52·8
H 203	100	87·7	74·5	83·0
H 24	110	60·5	61·7	60·9
Total	955	—	—	—
Average	106	71·7	68·6	70·0

It will be seen that in area 1 in six clones higher percentages were obtained on stocks that were dormant at the time of budding while in four clones the reverse was the case. The difference between the average percentages in the two classes of stocks is negligible.

In area 3 higher percentages were obtained on dormant stocks in four clones, in four clones higher percentages were obtained on active stocks, while in the remaining clone the percentages were identical. Again the difference between the average percentages can be considered to be negligible.

It would appear, therefore, from this record that for estate practice the question of whether each individual stock is active or dormant at the time when it is desired to start budding is not worth considering, though it might be desirable to start budding when the majority of the stocks were beginning to show active growth, if such a period could be determined.

WEATHER CONDITIONS

Mann examined this factor and compared results from budding in (1) showery weather, and (2) drought conditions. His figures show that little difference was found at the first opening of the buddings for examination but that the percentage of final successes was considerably greater when the budding had been done during showery weather.

Statements have sometimes been made as to the importance of the actual climatic conditions at the time of budding and it may be as well to examine this point first.

Budding is not usually attempted on wet days and apart from fine distinctions as to the differences in mean temperature humidity, degree of sunlight, etc., of which data are not available in the present instance, budding days can be roughly divided into sunny and dull days. Table 3 gives the results from such a procedure.

Table III

Results of Budding under different weather conditions

Clone	Weather conditions on day of budding	Percentage success	
Area 1			
H 411	Dull	50·8	
Cuilcagh 5	Dull	83·0	
Mirishena 2	Dull	45·0	Average 49·5
Mirishena 11	Dull	19·4	
H 2	Dull morning, hot sunny afternoon		71·4
Nakiadeniya 10	Sunny and very hot	88·1	
Eladuwa 1	Sunny and dry	61·4	
Wawulugala 20	Sunny and dry	85·0	Average 76·2
Govinna 1368	Sunny and dry	58 6	
Yogama 21y	Sunny and dry	88·1	
Area 3			
Udapola 24	Dull and sultry	68·6	
H 203	Dull	83·0	Average 70·8
H 24	Dull and drizzling	60·9	
H 2	Dull morning, hot and sunny afternoon		47 5
H 401	Sunny and very hot	93·5	
H 439	Sunny and very hot	88 6	
Milleniya 162	Sunny and dry	61·2	Average 74·1
Hillcroft 34	Sunny and dry	74·3	
H 47	Sunny and dry	52 8	

It must be stated that in a few cases on hot days budding was stopped between 10 a.m. and 3 p.m. while in other cases budding was continued all day.

It has usually been presumed that dull cool weather is preferable for budding but the above record does not appear to support this, in fact in both areas the largest percentages of successes were obtained in clones which were budded on sunny days especially noted as being very hot.

It may be argued that the weather on the day of budding is of comparatively small importance compared with the general climatic conditions during the month following budding. This may be so, but unfortunately few planters will be able to predict these conditions with certainty, and few in Ceylon have the ready means of obtaining frequent long range meteorological forecasts. The question of rainfall is probably more important and will be separately considered, but it may be concluded from the figures given that there is no reason why budding in the field should not be done on hot sunny days and that if the climatic conditions on the day of budding have any effect at all it is probably masked by the more potent factors such as the personal factor, the condition of the budwood, and the individuality of the clone.

An attempt will now be made to study the influence of rainfall for a short period before and after budding. Mann found that appreciably better results were obtained in showery weather than under "drought conditions."

In the present instance none of the budding was done in weather that could be described as "drought conditions." In table 4 the rainfall for 5 days before budding and 10 days after budding is shown and the clones are divided into two classes: in each area the clones above the line were budded during periods of more frequent and heavier rain than those below the line. The former appeared to have gained no advantage however, in fact the highest percentages of success are found in the periods of least rainfall. It may well be, however, that the difference between the conditions under which these two classes were budded was not sufficient to effect the issue, or was masked by more potent factors.

Table IV

Record of rainfall in inches five days before and ten days after budding in the field

Area 1	Days before budding					Day of budding	Days after budding									Percentage successes	Average
	5th.	4th.	3rd.	2nd.	1st.		1st.	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	
Clone																	
H 411	—	—	—	·08	—	—	·11	·06	·10	—	·31	—	·04	·55	·10	·04	50·8	
Cuilcagh 5	—	—	—	·08	—	—	·11	·06	·10	—	·31	—	·04	·55	·10	·04	83·0	
Mirishena 2	·10	—	·31	—	·04	·55	·10	·04	·13	—	1·26	—	·47	·18	·53	·62	45·0	51·3
Mirishena 11	—	—	·31	—	·04	·55	·10	·04	·13	—	1·26	—	·47	·18	·53	·62	19·4	
Govinna 1836	—	—	·08	—	—	·11	·06	·10	·10	—	·31	—	·04	·55	·10	·04	58·6	
H 2	—	—	·13	—	·02	—	—	—	—	—	—	—	·08	—	—	—	71·4	
Nakiadeniya 10	·13	—	·02	—	—	—	—	—	—	·08	—	—	—	—	—	·20	88·1	
Eladuwa 1	—	—	—	·08	—	—	—	—	—	·20	·12	—	—	—	·13	·15	61·4	78·8
Yogama 21Y	—	—	—	—	·08	—	—	—	—	—	·20	·12	—	—	—	·13	88·1	
Wawulagala 120	—	—	—	·08	—	—	—	—	—	·20	·12	—	—	—	·13	·15	85·0	
Area 3																	
H 24	—	·31	—	·04	·55	·10	·04	·13	·80	—	1·26	—	·47	·18	·53	·62	60·9	
H 203	—	·08	—	—	·11	·06	·10	—	·31	—	·04	·55	·10	·04	·13	·80	83·0	65·6
H 47	—	—	·08	—	—	·11	·06	·10	·10	—	·31	—	·04	·55	·10	·04	52·8	
H 2	—	—	·13	—	·02	—	—	—	—	—	—	—	·08	—	—	—	47·5	
H 401	—	·13	—	·02	—	—	—	—	—	—	·08	—	—	—	—	—	93·5	
H 439	·13	—	·02	—	—	—	—	—	—	·08	—	—	—	—	—	·20	88·6	72·3
Milleniya 162	·02	—	—	—	—	—	—	·08	—	—	—	—	—	·20	·12	—	61·2	
Udapola 24	—	·02	—	—	—	—	—	—	·08	—	—	—	—	—	·20	·12	68·6	
Hillcroft 34	—	—	—	—	·08	—	—	—	—	—	—	·20	·12	—	—	—	74·3	

THE PERSONAL FACTOR

The personal skill of the budder has undoubtedly a potent influence on success. In the present case all the budding was done by two men, both of whom did a part of the budding of each clone, so that for comparative purposes the personal factor can be disregarded.

THE CONDITION OF THE BUDWOOD

This is probably the most potent factor in influencing the success of budding rubber. It is rather difficult to analyse the causes leading up to unsatisfactory peeling and general poorness of budwood. It appears certain that individual clones differ inherently in this respect but Mann has also pointed out the great variation in successes that he obtained from budwood from different trees of the same clone. It would appear that the quality of giving a large percentage of successes in budding is one which should have considerable weight in selecting a clone for extensive propagation. Apart from this it would appear hard to see what practical steps can be taken in the matter beyond ensuring as far as possible that the plants in the budwood multiplication nursery are in the most vigorous possible state.

REBUDDING OF FAILURES

The statement has been made in Ceylon that when a bud has failed there is little chance of success by rebudding the stock on the other side until a period of about four months has elapsed. While this may be true of small stocks it has been strikingly disproved in the present instance in the case of two-year-old stocks such as were used in area 3. As reserve stocks were in hand for replacing failures, and as, in the event of final failure, the original stock would in any case be uprooted it was thought worth while to rebud the original stocks on the other side when a failure was recorded. The results are found in table 5 altogether with the results of the original budding.

Table V

Percentage successes obtained by rebudding two-year-old stocks on the opposite side when the original budding had failed.

Clone	Pencentage successes of original budding	Percentage successes of rebudding on the opposite side of the stock
H 2	47·5	64·1
H 401	93·5	100·0
H 439	88·6	75·0
Hillcroft 34	74·3	82·1
Milleniya 162	61·2	79·0
Udapola 24	68·6	78·1
H 47	52·8	85·3
H 203	83·0	100·0
Average	71·2	82·9

All stocks were rebudded within two months of the original budding. One clone is not included as the second examination had not been made at the time of writing. It must be borne in mind that a considerably smaller number of stocks was dealt with in the rebudding than at the original budding, but the fact that the average percentage of successes obtained is actually higher than at the original budding while conditions were approximately the same indicates that it is well worth while re-budding large stocks again on the other side without delay.

COMPARISON WITH BUDDING IN THE NURSERY

No exact comparison with nursery budding is available in the present instance since the same clones (except H2) were not budded in the field and the nursery. The percentage of successes obtained by budding in the nursery (for area 2) is however given in table 6 for general comparison.

Table VI

Percentage successes obtained by budding on one-year-old stocks in the nursery.

Clone	Percentage Successes
H 2	78·9
H 75	87·0
H 445	97·0
P 5	94·5
P 12	96·5
H 400	81·0
H 82	84·0
H 140	94·0
H 440	97·0
H 26	96·0
Average	90·6

The average percentage of successes is certainly considerably higher in the nursery than in the field but it must be remembered that the nursery budding was all done on vigorous one-year-old stumps. Better results in the field could have been anticipated on one-year-old stumps, though it is unlikely that they would have achieved the same vigorous growth as in the nursery.

ACKNOWLEDGMENT

All the budding work referred to was done under the immediate supervision of Mr. T. B. Ranaraja, Assistant in charge of the Iriyagama Division, who also took the records on which the conclusions arrived at in this article are based. He was assisted in this work by Mr. A. E. Wickramasinghe, Conductor.

SUMMARY AND CONCLUSIONS

1. The results of budding seventeen Ceylon clones in the fields are discussed.

2. It was found that there was no apparent advantage in the stock being in a state of active growth at the actual time of budding.

3. There was no apparent advantage in budding on dull days rather than on hot sunny days; in fact the highest percentages of successes were obtained under the latter conditions.

4. No budding was done under drought conditions but from an examination of the rainfall five days before and ten days after budding it appeared that a higher percentage of successes was obtained in the periods of lesser rainfall.

5. Considerable differences in the percentages of successes obtained were apparent in different clones and it is believed that the individual suitability of a mother tree for successful budding and the state of the budwood used are two of the most important factors influencing success.

6. It was found that large two-year-old stocks could be successfully budded on the other side soon after the original budding was definitely recorded as a failure.

7. Considerable greater success was obtained by budding on vigorous one-year-old stocks in the nursery than on stocks two years old or more in the field.

CONTRIBUTIONS FROM THE RUBBER RESEARCH SCHEME, CEYLON

REPORT ON SULPHUR DUSTING EXPERIMENTS ON GONAKELLE ESTATE

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1. *The Experimental Area.*—The total area of rubber on Gonakelle Estate is 93 acres, consisting of three fields of approximately 45, 40, and 8 acres respectively. The latter field is situated about $\frac{1}{4}$ mile distant from the main portion of the rubber, and served as an untreated control in the dusting experiments. Roughly speaking, the two main fields consist of relatively narrow strips planted down a steep hillside from an elevation of over 3,000 feet down to about 1,500 feet. Whereas one field is well roaded, having a path "zig-zagging" from the top to the bottom, the other has few paths, such as there are being badly placed for dusting purposes. This matter has an important bearing on the success of the operations, as indicated below.

The rubber is mature and well grown for so great an altitude, and has not been tapped for some years. Before the dusting was commenced the intensity of *Oidium* was judged to be approximately equal in the three fields, the extent of defoliation being, perhaps, slightly less in the control block. Every tree was affected to a greater or less degree, and it was estimated that approximately 30% of the trees had been completely defoliated. The fungus was active when dusting was commenced.

2. *The Dusting Operations.*—For the most part the Björklund Duster was used, as in the experiments in Matale. With the exception of a few minor points due to the vibration of the two-stroke engine the machine gave entire satisfaction. In conjunction with the dusting experiments a trial machine of British manufacture was tested.

Two kinds of sulphur were used:

(1) "Acme 300" sulphur dust manufactured in America.

(2) "Flotate" sulphur from the Kawah Poetih volcanic deposits in Java.

The price of the American sulphur f.o.r. Colombo is about 13½ cents per lb., whereas for the Java product the corresponding cost is about 6½ cents per lb., the difference in price being largely due to the heavy freight charges from America. The only advantage which the American sulphur appears to possess is that it may be used without any preliminary treatment. "Flotate" sulphur, on the other hand, must be dried in the sun for a few hours before use, and may be passed through a sieve to advantage. This operation, however, costs not more than about 1/10 cent. per lb., so that it would appear that the extra cost of the more specialised product is not justified. When satisfactorily dried "Flotate" sulphur possesses as good cloud-forming properties as "Acme 300," and its fungicidal properties appear to be at least as good. The conclusion that "Flotate" sulphur is preferable to "Acme 300" should not be interpreted as a general statement unfavourable to specially prepared American sulphurs. Price is a very important factor, and if an American firm can place on the Ceylon market a suitable article at a price competitive with that of Java sulphur, its use must be considered. At the present time it is not known whether the Java sulphur possesses any advantages over American sulphur on account of its acid content.

A total quantity of 6,200 lb. of sulphur was applied to the experimental fields on Gonakelle, 4,000 lb. of "Acme 300" dust being first applied in four applications followed by 2,200 lb. of "Flotate" sulphur in three applications. In all an average of 73 lb. per acre was applied. Mechanical trouble with the experimental machine somewhat interfered with the later dusting operations, with the result that portions of the rubber have received 7 applications while others have had only 6 dustings. The first application was made on May 7th, and 8th, 1930. Subsequent dustings followed at approximate fortnightly intervals, the final application being made on August 19th, and 20th.

Owing to the steepness of the land and scarcity of the paths in part of the experimental area each application occupied two days, so that an average area of only 42½ acres was treated per day. The dusting operation was confined to the mornings. The coolies were seldom able to return to the lines before about 2 p.m. and were not, therefore, required to work in the afternoons. All the work was personally supervised.

3. *Quantities and Costs.*—The following figures represent the approximate costs of the dusting operations on Gonakelle. It is impossible to give exact figures owing to the complications introduced by the testing of the experimental British machine. The figures are of little value as a gauge of the general cost of

sulphur dusting owing to the excessively high price of the American sulphur. Depreciation of the machine and cost of special supervision are not included.

			Rs.	cts.
Sulphur.	(1)	4000 lb. "Acme 300" @ 13·3 cts.	532	00
		2200 lb. "Flotate" @ 6·6 cts.	145	20
		(costs are excluding transport from Colombo)		
Labour.		140 coolies @ -/60 cts.	84	00
Petrol.		7 gallons @ Rs. 1-75	12	25
Oil.		1½ gallons @ Rs. 4-50	6	75
		Rs.	780	20

This is equivalent to about Rs. 9-25 per acre. It is again emphasised that this figure does not represent the economic cost of sulphur dusting in Ceylon.

4. *Results.*—Before reporting the results of the dusting experiments it is necessary to consider the condition of the foliage when the dusting was started and during the course of the operations. The normal "wintering" process occurs on Gonakelle during February, March, and April. When dusting was started on May 7th most of the trees had put on their new foliage and had suffered as the consequence of a severe *Oidium* attack. It was estimated that about 30 per cent. of the trees had been completely defoliated. These trees put out a second crown of foliage during the course of the experiments, so that there was at all times a proportion of the trees in young leaf. In addition a considerable percentage of trees underwent a secondary "wintering" in July and August so that there was a large quantity of young leaf in August and early September. This secondary "wintering" is normal in parts of Uva and is doubtless due to a prolonged period of dry weather following the N. E. Monsoon.

Oidium was active throughout the course of the experiments but did not cause as severe leaf-fall as in March and April. It became more virulent in the control field after the normal secondary wintering referred to above, and its increase in virulence appeared to be associated with the advent of showery weather.

It may at once be stated that the benefit in the foliage due to the sulphur dusting was disappointing. This is considered to be chiefly due to the fact that the dusting was carried out at the wrong time of the year. It was the intention to commence dusting early in April, but owing to unforeseen delays in shipping the sulphur from America, the start was postponed until May 7th, by which time the foliage had already suffered severely from the disease. As far as the control of the fungus is concerned, however, very definite results were obtained.

In considering the results of the dusting it is necessary to distinguish between the two treated fields. It has already been mentioned that whereas one field is well "roaded," the other is poorly provided with paths. In order to determine whether it is necessary to apply the sulphur carefully to every portion of the rubber, or whether, once a good cloud of sulphur has been projected, the breezes will effectivly distribute it to all parts, the latter area was dusted chiefly from such paths as existed. As a consequence the treatment was comparatively ineffective, and only those portions of the field to which the sulphur could be easily applied have benefited to any marked extent. The valuable conclusion is drawn that it is of the utmost importance to ensure that every portion of the rubber receives its full quota of sulphur. On steep land this is often a matter of great difficulty, and would probably be a limiting factor to the success of sulphur dusting on some mid-country estates. Attention is directed below to the results obtained on the well "roaded" field in which it was possible to dust every portion from the paths.

The foliage of the dusted and control fields was carefully examined on September 4th and 5th, and the following points were noted:

(1) In the dusted field about 15 per cent. of the trees were or had recently been in young leaf, and in every case examined the preceding defoliation was of the normal secondary type described above. In the control field the corresponding proportion was about 30 per cent. the defoliation in about half these cases being due to *Oidium* attack in the previous month or two.

(2) In the dusted field 38 trees in young leaf were examined, and in every case *Oidium* infection was either absent or slight. Leaf-fall was negligible. In the control field 48 such trees were examined, *Oidium* infection being classed in all cases as moderate or severe. The extent of leaf-fall was considerably greater than in the dusted field.

(3) There was an abundance of healthy flower in the dusted field, and a small quantity in the control.

(4) A small number of trees in the dusted field which had refoliated during the dusting operations appeared to be quite free from the disease, while, of a total of 240 trees examined, 31 per cent. showed only mild secondary attack. In the control field no entirely healthy trees were found, and the proportion with mild secondary attack was 10 per cent.

(5) A large percentage of trees in both areas possessed a thin crown of distorted leaves, mainly the result of *Oidium* attack before the dusting operations were commenced.

The above remarks apply only to the control field and the well "roaded" dusted field.

5. *Conclusions.*—As the result of the dusting experiments and other observations on Gonakelle the following conclusions have been drawn:

(1) "Flotate" volcanic sulphur from Java is as effective a fungicide as the more specially prepared "Acme 300" dust from America, and is preferable on account of its cheapness.

(2) In order that the dusting operations should achieve the maximum success they should be carried out during the period of refoliation after the normal "winter." The applications on Gonakelle were started too late in the year. It is probable that the first application should be made at the first appearance of young leaf after "wintering." This matter is to be investigated in further experiments to be carried out in Matale.

(3) The importance of ensuring that every portion of the rubber receives its full dose of sulphur is stressed. Steep land with few convenient paths may be very difficult and slow to dust effectively.

(4) Severe attacks of *Oidium* appear to be associated in the Passara district with showery weather. This may appear at first sight to be contradictory to the previous conclusion that a dry atmosphere is the most important climatic factor favouring the disease. It must be noted, however, that Passara is a dry district, and the humidity between showers is relatively low. It is possible that the showers provide the quantity of moisture necessary to the vegetative growth of the fungus mycelium, the intervening dry spells being favourable to the production of the conidia.

(5) Although the dusting operations, as judged by the general appearance of the treated rubber, cannot be considered highly successful, it is considered that the experiments, as such, have fulfilled a useful purpose in elucidating several problems in connection with the treatment.

6. *Acknowledgment.*—Thanks are due to Mr. G. Kent Deaker, Superintendent of Gonakelle Estate, for his kind co-operation in these experiments.

REPORT IN CONNECTION WITH VISIT TO THE EAST
A COMPARISON OF METHODS OF PREPARING PLANTATION RUBBER IN CEYLON, MALAYA AND JAVA

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FUNDAMENTAL factors which may affect the preparation and properties of rubber in the three countries are differences in type of soil and differences in temperature and humidity.

Soil.—In Ceylon most of the rubber is grown on undulating land some of which is covered with huge boulders. Neither in Malaya nor Java are conditions so hilly. The impression gained was that agricultural operations and latex collection are difficult in Ceylon, somewhat easier in Malaya and least difficult in Java. There are considerable differences in the appearance and physical texture of the soil in the three countries, but no opinion of value as to their comparative fertility could be formed in the short time available.

Climate.—The temperature in the rubber growing districts of Ceylon is about 5° lower than in Malaya and Java. For this reason fermentation of latex does not occur so readily in Ceylon. The lower temperature affects the growth of the trees and the rate of bark renewal. The trees take longer to reach maturity in Ceylon and it is customary during tapping to take much thinner shavings than elsewhere to allow for slower bark renewal.

Although the rainfall is abundant in all three countries the atmosphere in Ceylon is not so heavily charged with moisture. Crepe rubber can therefore be dried in less than a week when the weather is favourable, whereas in Java* it is necessary to employ artificial heating at night-time and in Malaya great care is necessary with regard to the position, dimensions and ventilation of the drying room.

During my visit there was a considerable amount of morning rain in Ceylon which interfered with tapping. The tapping intervals were therefore very irregular. Malaya and Java were more fortunate. Whilst the main features of rubber preparation are the same in all three countries, differences in detail have developed and the following is an attempt to summarise them.

* The preference for artificially heated drying sheds for crepe rubber in Java is in much lesser way a consequence of an extraordinary high content of moisture in the air than of the desire to be independent of the climate and the time of day as well as to be able to manufacture a rather thickish crepe in order to obtain a higher working capacity of the milling battery. During the dry season crepe rubber in Java will be dry in air at ordinary temperature within a week's time, just the same as in Ceylon. By employing artificial heating the danger of developing mould on crepe even in exceptionally cold and rainy weather is practically nil.—(Comment by the Director of the Java Proefstation voor Rubber).

Operation	Ceylon	Malaya	Java	Comments
Tapping	Half spiral cut 4-6 ins. per annum.	Chiefly V cut 9-12 in. per annum.	Half spiral cut 9-12 ins. per annum.	Ceylon cuts are thinner and less steep than elsewhere owing to slower bark renewal caused by climatic differences.
Latex collection	Latex is collected in coconut shells hung on an ingenious type of spout. After the collection of the latex the cups are sometimes inverted on sticks or left lying on the ground.	Latex is collected in porcelain or glazed earthenware cups hung on wire loops round tree. Glass cups are sometimes used. Aluminium cups are not favoured because they quickly become hot in immature areas and during the wintering season, and the film of latex left in the cups after collection becomes tacky.	Latex is collected chiefly in aluminium cups hung on loops round trees. These are taken every day to the factory by the tappers, thoroughly cleaned and dried and inspected by the factory assistant.	The temperature in the rubber growing districts of Ceylon is lower than in the other countries and fermentation of the latex, causing bubbles in the rubber, does not occur so readily. Hence there is not the same obvious need for cleanliness. It is probable that strict attention to the cleanliness of cups in Ceylon would result in an improvement in the average inherent quality of rubber from the Island.
	*To prevent premature clotting an anticoagulant is necessary on a few estates and for this purpose sodium sulphite is used.	It is frequently necessary to employ an anticoagulant to prevent premature clotting and for this purpose sodium sulphite is used.	The addition of anticoagulants is seldom necessary. Sodium carbonate is officially recommended as a remedy against premauture clotting in the case of sheet manufacture and sodium sulphite for crepe.	The use of sodium carbonate as an anticoagulant was found to cause bubbles in Ceylon and Sumatra. Some technologists prefer ammonia as an anticogulent as it lowers the viscosity of the latex and enables dirt to settle out more easily. The possible effect of ammonia on brass in strainers resulting in the presence of copper in the rubber was discussed at the Java Conference but no definite conclusion was reached. This is a point which requires investigation.

* Sodium sulphite has the disadvantage of delaying drying and absorption of smoke. Ammonia would probably be more satisfactory but has not been tested in Ceylon (Comment by Chemist in Ceylon—T. E. H. O'Brien).

Operation	Ceylon	Malaya	Java	Comments
Latex treatment	Rubber content of latex determined by metrolac or glass hydrometer.	Rubber content of latex determined by metrolac. Daily crop estimates are usually made by weighing the wet rubber after a definite period of dripping, making allowance for the moisture content. For the estimates of dry rubber content of preserved latex for export trial coagulations are made.	Rubber content of latex determined by trial coagulation and crepeing.	The Java Proefstation voor Rubber considers that the use of specific gravity instruments for the determination of the dry rubber content of latex is unsound. Scientific workers in Malaya do not consider latexometers as accurate as trial coagulations, but consider them sufficiently accurate for the control of standardisation of latex for coagulation purposes. The opinion in Ceylon is that the results given by glass hydrometers are as accurate as those given by trial coagulation, as carried out on estates.
	Latex strained before dilution.	Latex strained before dilution. Settling tanks are now being installed in which diluted latex is placed, in order to separate sand. Vertical sieves for straining which have been used on a few estates for years are being recommended for all estates.	On some estates elaborate sieves are built into tanks for straining before and after dilution.	Great interest was displayed at the Java Conference in a series of graded vertical sieves; which allowed the dirt to settle to the bottom of the containing vessel so that there was less likelihood of dirt penetrating through the meshes of the sieve.
	*More acetic than formic acid is used for coagulation.	More formic than acetic acid is used for coagulation.	More than 90 per cent. of the estates use formic acid for coagulation.	

* The use of formic acid is extending in Ceylon and probably now exceeds that of acetic acid. It causes difficulty in sheet manufacture on certain estates owing to rapid coagulation. (Comment by Chemist in Ceylon, T. E. H. O'Brien).

Operation	Ceylon	Malaya	Java	Comments
Crepe manufacture				
(a) bulking and dilution	Latex as received is poured into Shanghai jars and then diluted to 20 per cent. dry rubber content.	Latex as received is usually poured into Shanghai jars and diluted to 20 per cent. dry rubber content.	Latex is bulked in tiled tanks in factories visited and diluted to 20 per cent. dry rubber content.	
(b) bisulphite	Bisulphite is added to obtain pale colour.	Bisulphite is added to obtain pale colour.	Bisulphite is added to obtain pale colour.	
(c) period coagulum in serum	Coagulum is removed the day following the addition of acid.	Coagulum is removed the day following the addition of acid.	Coagulum is removed the day following the addition of acid.	
(d) machining	Coagulum machined about five times.	Coagulum machined about twelve times.	Coagulum machined about twelve times.	The coagulum in Ceylon is mostly converted into lace crepe which is blanketed when dry. In Malaya and Java the coagulum is converted into thin crepe of even texture which requires no further treatement when dry.
(e) drying	The drying room is usually over the factory, and when the weather is favourable the crepe can be dried in 5 days. In some factories the crepe is dried by heating in air at 140°F for 45-60 mins. In this case it is rolled on to drums in layers and cut into mats. Hot air drying is more expensive than drying in air at ordinary	The drying room is frequently over the packing room. Crepe takes 9 days or more to dry.	It is usual to heat drying room at night with hot water pipes; otherwise the crepe may take as long as 21 days to dry.	The "mat" method of drying employed on some estates in Ceylon should be more widely known.

Operation	Ceylon	Malaya	Java	Comments
(e) drying (*contd.*)				
	temperature and is being discontinued. It is found that crepe dries as quickly in air without heat in mat form as in single lengths. This method is therefore employed on a number of estates with a considerable saving in space and labour.			
(f) principal defect	Mouldy crepe due to slow drying in wet weather gives considerable trouble on some estates. On blanketing this causes a discolouration of the crepe. The remedies suggested by Mr. O'Brien were cleanliness, washing drying room with 2% formalin, and the use of paranitrophenol.	Spot disease due to slow drying or dampness.	Spot disease due to slow drying or dampness.	The defects in Ceylon are peculiar to blanket crepe and those in Malaya and Java to thin crepe.
Sheet manufacture				
(a) bulking	Latex as received is usually poured into Shanghai jars. A few estates employ bulking tanks.	Latex poured into tanks.	Latex poured into tanks.	
(b) dilution	Diluted to 15% dry rubber content.	Diluted to 15% dry rubber content.	Diluted to 15% dry rubber content.	

Operation	Ceylon	Malaya	Java	Comments
(c) coagulation	Acid added in jars or tanks and the latex transferred quicky to dishes. Sometimes latex is coagulated in shallow troughs and the coagulum handled in long lengths.	Acid added in tanks and vertical partitions inserted.	Latex transferred to dishes and acid added to each dish.	A study is being made at the Rubber Research Institute, Malaya, with regard to the most suitable depth of tank.
(d) period coagulum in serum	Coagulum machined the day after the addition of the acid.	Coagulum machined the day after the addition of the acid.	Coagulum machined the same day as the addition of the acid.	
(e) machining	Coagulum passed through a series of hand rollers on most estates.	Coagulum passed through a series of power driven rollers.	Coagulum passed through a series of power driven rollers.	One estate manager in Malaya had studied the machining of sheet very thoroughly and by increasing the depth of latex in the coagulating tanks thus producing a wider sheet, and by speeding up the machines had appreciably decreased the cost of this operation. The problem is also under investigation at the Rubber Research Institute, Malaya.
(f) soaking and dripping	Wet sheets allowed to drip in shade for about an hour.	Wet sheets allowed to drip in shade for about an hour.	Sheets soaked overnight in water and then allowed to drip.	The soaking process in Java is stated to prevent the development of mould.

Operation	Ceylon	Malaya	Java	Comments
(g) smoking	Sheets smoked to a fairly dark colour. Many types of smoke-house.	Sheets smoked to a light colour. Elaborate smoke-houses.	Sheets smoked to a dark colour. Cheap smoke-houses which are probably efficient.	Professor de Vries expressed the opinion that it was unwise to encourage the market to demand a light coloured smoked sheet which might become mouldy very easily. The Rubber Research Institute, Malaya, is continually advocating the preparation of a darker smoked sheet. Considerable interest in the construction and dimensions of smoke-houses is being taken in Ceylon and Java and improvements are to be expected in the next few years.
(h) mould prevention	Paranitrophenol is used on a number of estates. Sometimes the sheets are soaked in it and sometimes it is added along with the coagulant.	Paranitrophenol was used extensively during the restriction period, but owing to additional cost its use has decreased considerably now that rubber is again placed on the market shortly after preparation.	Paranitrophenol is not required.	Machining on the day of coagulation, followed by soaking and heavy smoking in Java, tends to produce a sheet which vulcanises as slowly as crepe in a rubber-sulphur mixing.
(i) packing	Lining sheets used in packing. The rubber is not usually pressed into cases on account of complaints of massing. The cases therefore contain somewhat less than 220 lb. of rubber (170-180 lb.). 224 lb. per case is recommended by the Rubber Research Scheme.	Lining sheets are used in packing of the same grade as the contents. The rubber is usually pressed into cases which hold 224 lb., so that ten cases contain exactly one ton of rubber. In the case of thin crepe about 175 lb. are pressed into each case.	Lining sheets used in packing. The rubber is pressed into cases which hold about 220 lb.	An estate in Malaya supplying direct to the manufacturer baled all its rubber. The massing of rubber is of no importance unless the rubber has to be resorted at the docks or used by manufacturers without adequate machinery.

GENERAL COMMENTS ON METHODS OF PREPARATION

A. *Preparation of intrinsically uniform rubber.*—Owing to local modifications in the method of preparation it is to be expected that there will be general differences in the vulcanising properties of rubber from Java, Malaya and Ceylon. The most striking is likely to occur in the case of smoked sheet which, owing to machining soon after coagulation, soaking in water overnight, and heavy smoking, probably vulcanises more slowly when obtained from Java than when obtained from Ceylon or Malaya.

On the whole it is considered that methods of preparation do not differ greatly on estates in the same country and that the important source of variability is due to the varying characteristics of individual trees (see de Vries, Estate Rubber, p. 50). As long as rubber is the product of life processess in a tree it will not be possible to obtain strictly uniform material without submitting it to drastic chemical purification. Nevertheless it is possible to prepare much more uniform material than at present. For this purpose bulking on a large scale should be encouraged and when the standard method of preparation is found to yield a material with abnormal vulcanising and mechanical properties the method of preparation should be modified (Cf. Programme of Work, January 1st, 1930). This is the practice in connection with the preparation of "Certificate Rubber" in Java. Professor de Vries considers that the demand for this type of rubber is disappointing. On the other hand it is possible that the rubber is not as uniform in manufacturing operations and service as the laboratory tests indicate (Cf. Dinsmore and Zimmerman, Ind., Eng., Chem., 18, 1926, p. 144). It is important that the results of laboratory tests should bear a relation to results obtained in commercial practice, and this is a subject to which a considerable amount of attention has been given by the London Staff of the Rubber Research Scheme. The information obtained is of practical value in connection with the attempts now being made to encourage the preparation of uniform rubber throughout Ceylon.

As the area under budded rubber increases variations in the properties of rubber will probably decrease, particularly if care is taken to ensure that no tree is used as a source of budwood which yields rubber with abnormal properties when prepared by a standard method. This question is under consideration in London and has been studied elsewhere (*India Rubber Journal*, November 16, 1929, p. 159).

When the rubber tree population becomes less mixed it may be possible to prepare uniform rubber throughout Ceylon by a careful standardisation of the processes of preparation, but at present local modifications are necessary.

Acting Director, Rubber Research Institute, Malaya.

Comment by B. J. Eaton.—"In Malaya, I consider the lack of uniformity is due mostly to differences in methods of preparation on different estates. The considerable bulking of all the latex on any one estate eliminates differences due to varying characteristics of individual trees. The fact that the rates of vulcanisation of smoked sheet and thin pale crepe in Java are very similar, is probably due to the machining on the day of coagulation and the soaking overnight in water, whereas the coagulum for crepe manufacture is machined on the day after coagulation.

"The more rapid rate of vulcanisation of sheet compared with thin pale crepe in Malaya is due to the fact that generally the coagulum for both sheet and crepe is machined on the day after coagulation."

Author's Comment.—The views expressed in this report are partly based on results obtained with crepe and sheet from latex from different estates in Ceylon using the same method of preparation. The question is receiving attention in connection with the survey of the intrinsic quality of Ceylon rubber now being made.

B. *Dirt.*—Very few estates realise how important it is to keep out of the latex fine particles of dirt which are too small to be removed by straining. The use of *sheraties* (coconut shells), which is the general practice in Ceylon, is a doubtful economy and may be more instrumental in limiting the use of rubber than is generally realised.

Comment by B. J. Eaton.—"During this year much attention has been paid to this problem and large scale experiments have been carried out by the Chemical Division of the Rubber Research Institute of Malaya on estates. A vast improvement has been effected by (a) use of settling tanks in which diluted latex is allowed to stand for about 10-15 minutes before straining and transfer to coagulation tanks, and (b) by the advocation and use of vertical strainers."

Village Sheet.—An interest was taken in the preparation of smoked sheet rubber on small holdings in Ceylon. As the latex from which the individual sheets are prepared is obtained from a small group of trees, the rubber must be variable, but it is probably averaged by the various brokers who handle it. Nevertheless it is expected that batches of 100 lb. will vary more than the corresponding amounts from large estates. The method of sun drying is open to criticism as it may cause deterioration of the rubber.

Comment by B. J. Eaton.—"In Malaya co-operative factories and smokehouses are being started to improve and render such rubber more uniform. It is also anticipated that a higher market price equivalent to that obtained by large European managed estates will result."

For the information contained in this report the author acknowledges his indebtedness to Professor de Vries and Dr. Riebl in Java, Major B. J. Eaton in Malaya and Mr. O'Brien in Ceylon who all devoted a considerable amount of time to enable him to obtain the maximum advantage of his tour in the East. He also appreciates their kindness in correcting and commenting on this report.

A FRUIT INDUSTRY FOR THE GOLD COAST*

THE GOLD COAST CLIMATE

THE Gold Coast is situated wholly within the torrid zone and has a mean annual rainfall between 24 inches in the coastal savannah and 88 inches in the rain forest. There is a marked double rainy season.

The mean annual shade minimum temperature in the coastal savannah lies between 71 and 75 degrees, the mean annual shade maximum for the same type of country being 83°-87°. In the rain forest mean shade minimum falls between 67° and 71° with a mean maximum of 83°-89°.

The mean temperature range in the inland savannah is generally greater, reaching 26° in some districts.

The mean annual relative humidity lies between 71 and 88 per cent. with a very marked drop to as low as 20 per cent. in the Harmattan season, during December and February.

A FRUIT INDUSTRY FOR THE GOLD COAST

An industry in the fruit mentioned is limited at the present time to *Lemons* and *Grape Fruit,* these crops being easily cultivated and handled. The most important factor however is that the fruit would be easily marketable in the United Kingdom as compared to other fruits, which would have to meet severe competition from other countries.

COMMENCING THE INDUSTRY

The industry being a specialised one, where care is required in cultivation, selection of varieties, weeding, mulching, pruning, reaping, handling, grading, packing and shipment, it is obvious it would be useless to attempt the cultivation of either lemons or grape fruit in the same manner as cacao is cultivated by the majority of the farmers at the present time. A number of individually owned plantations with a central packing house, or plantations commenced on a bonus system, as has been done with coffee in this Colony, even with co-operative management, would be doomed to failure from the commencement.

The trees have to be grown on plantation principles and receive care and attention throughout the whole period from seedlings to old age, and the fruit "picked." No fruit of any description is picked in this country and even on Agricultural Stations, unless supervised by a European, the method of collecting is by beating or shaking the branches and allowing the fruit to fall to the ground.

Having regard to the primitive methods of Agriculture in force at present and to the temperament of the African, the industry would have to be commenced and managed by Government, unless a European firm or company with a knowledge of, or interest in, the fruit industry, could be induced to obtain a concession for the purpose.

RAINFALL, SITUATION, SOIL

(a) *Grape Fruit.*—In the United States the trees are grown in many districts on every sandy soil with very low rainfall which requires irrigation. Large and good crops are produced under these conditions but insect pests cause a considerable amount of damage and production costs are ralatively high.

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* By G. H. Eady, (Gold Coast) in *Bulletin* No. 20 of the Department of Agriculture, Gold Coast.

At Aburi with a rainfall of 48 inches good crops are produced but in general a rainfall of under 50 inches is undesirable. In the West Indies grape fruit cultivation is successful in a high rainfall area of 250 inches per annum. A district with a rainfall of over 50 inches should be chosen and this should be fairly evenly distributed.

A site near a motor road or railway is an obvious advantage, other conditions being suitable, and should be chosen with due regard to the soil and rainfall conditions necessary. Flat land is suitable provided it is well drained but land with a moderate slope is preferable.

The best soils are deep loams, fertile, and well drained. Shallow, heavy, poorly drained soils are unsuitable and clay soil should be avoided. Trees on good fertile soil will produce heavy crops without the use of irrigation or artificial manures and production costs will be at a minimum. Many suitable situations exist in the Gold Coast.

(b) *Lemons.*—At Aburi, elevation 1,500 feet, rainfall 48 inches, the trees grow well and produce fairly good crops on very poor soil. The tree requires practically similar conditions of rainfall situation and soil, as the orange. The tree luxuriates in the tropics, grows well in the sub-tropics and will endure the mild frosts of the South of France. A rainfall above 50 inches is advisable, although in well-watered districts the trees will probably fruit well on less than this. A very humid atmosphere is detrimental to the production of good fruit, whilst a short resting period, such as is encountered during the Harmattan season, would be distinctly beneficial.

Conditions as to suitable situations are the same as required for grape fruit. The higher elevations up to 4,000 feet are preferable but unobtainable in this country. Strong winds are a disadvantage and strong sea breezes definitely harmful.

The type of soil in which lemons luxuriate is of a light rich nature on a marly or limestone formation, but the tree does well on any good rich soil such as may be found in many places in the Western Province of the Colony in well-watered areas.

SUPPLY OF PLANTS AND PLANTING MATERIAL

(a) *Grape Fruit.*—The most desirable characteristics are, thinness of skin, fine texture, yet strong enough to stand up to the handling and travelling necessary, smoothness, good and even colour without roughness or corrugations, and fruit of good shape. A minimum of seeds, pith and rag, is desirable, but sweetness is of little importance, providing the fruit possesses high juice content with a brisk and distinct flavour and is free from bitterness and too much acidity.

Certain trees at Aburi and on other Agricultural Stations possess these characteristics and large numbers of seedlings could be raised by budding on to sour orange stocks. "Marsh's Seedling," "Duncan," "Excelsior," "Hall," "McCarty," and "Triumph," varieties are being imported by the Department and budded plants could be raised from these.

(b) *Lemons.*—The chief characteristics desirable are good colour, smooth, even, thin yet tough skin and a brisk and distinct flavour. Fruit approximating to these desiderata exist at Abrui and on other stations Large numbers of budded seedlings could be raised on sour orange stocks or from seed if necessary. The Department is importing the following varieties from all of which budwood would be available within a few years: "Eureka," "Lisbon," "Villafranca," "Genoa," "Spanish."

NURSERY AND SEEDLINGS

(a) *Grape Fruit*: (b) *Lemons.*—Numbers of grape fruit and sweet orange trees in this country are destroyed by gummosis of the collar and stem for which reason a resistant stock is essential. The sour or Seville

orange is resistant or nearly so; and possesses certain other desirable characteristics of value. The first, or one of the first, operations after acquiring the land chosen for the plantation would be the selection of a site suitable for nursery. The seedbed need not be raised from the ground unless local conditions require such practice and seed from healthy, vigorous, well-grown trees obtained, preferably from only one tree. When the seedlings are about 8 inches high they should be transplanted into the nursery, 15 inches apart and 3 feet between the rows, taking care to discard all small, weak and diseased plants and those with deformed roots.

Budding may be undertaken whenever the seedlings are large enough and preferably about 10-12 inches from the ground, otherwise the stem may develop gummosis or collar rot. Small and backward seedlings should be destroyed. The usual practice should be followed in this operation which presents no real difficulties in this country. Budwood should only be cut from trees known to produce the right type of fruit in abundance and only from such trees as show the least tendency to single limb mutation.

Budwood may be kept for some time under suitable conditions transported to the nursery by the most direct route, or alternatively, seedling stocks could be raised and budded in the vicinity of the parent trees and the budded plants transported to the plantation.

PLANTING

(a) *Grape Fruit.*—All natural growth should be removed from the selected area and holes dug 25 feet by 25 feet apart each way. When removing plants from the nursery to the plantation all weak trees should be discarded as they are inferior to the well-grown ones and will always remain so. Young plants should each be provided with a stake to which they must be tied to encourage straight stems.

The actual planting operation would naturally follow the standard practice and needs no description here.

(b) *Lemons.*—A planting distance of 20 feet by 20 feet is recommended which gives 109 plants to an acre. A greater or lesser distance may be necessary according to the type of soil otherwise the procedure would be the same as given under grape fruit.

CARE OF THE YOUNG PLANTATION

(a) *Grape Fruit and* (b) *Lemons.*—Until such time as the trees come into good bearing the young trees require continual attention. Vacancies should be filled as soon as they occur in order to obtain trees of uniform growth.

Clean weeding is not recommended except for an area extending for three feet either side of each tree. Weeds and bush may be cutlassed when necessary and the trees mulched with the weeds cut from the centre of the rows. Pruning should be confined to removing branches and suckers that arise from undesirable positions and crossed branches, the object being to produce well-balanced trees with fairly open centres.

Whilst the grape fruit and orange require only a minimum amount of pruning the lemon tree demands almost constant attention. The tree should be regularly pinched back and built up wholly of short stocky branches strong enough to bear a heavy load. The tree should not be allowed to grow more than 8 feet to 10 feet high and all suckers and vigorous shoots removed as occasion demands.

CULTIVATION

With a medium rainfall, clean weeding of young grape fruit or lemon plantation is not recommended since the valuable surface soil would be lost by erosion and humus content quickly destroyed, apart from the damage to the feeding roots which lie close to the surface.

Cover crops should be encouraged whenever possible.

The addition of fertilisers will probably be necessary when the trees commence to bear but, provided good crops are produced, may not be required.

PROBABLE YIELD

(a) *Grape Fruit.*—Trees in full bearing are capable of yielding 500 fruits per tree.

A yield of 20,000 fruits per acre is within the limits of a healthy plantation.

Records of the individual yields of trees both at Tarkwa and Aburi, where the soil is very poor, average 300 fruits per tree over a period of several years. In this country there is a double fruiting season extending from March to June and September to December, the greatest proportion of fruit being produced during the earlier season.

(b) *Lemons.*—The fruiting season is much more irregular than with other citrus fruit, being produced in this country throughout the greater portion of the year. Pruning is an important operation in relation to production but if properly carried out good trees will yield 400-500 fruits per tree or 40,000 per acre per annum.

PICKING

(a) *Grape Fruit.*—This operation is as important as the actual production of the fruit and should receive very great care. Fruit must not be dropped or bruised or suffer mechanical damage whatsoever; otherwise a large percentage will be decayed before reaching distant markets.

Pickers, in addition to being taught that extreme care is necessary in handling the fruit, should wear gloves to avoid finger nail marks. Other points requiring attention are (*a*) The use of a type of clipper that will not injure the fruit. (*b*) Containers must be free from roughness, sand splinters, or any material likely to damage the fruit. (*c*) The stem must be cut flush with the button and no portion allowed to project beyond the fruit otherwise punctures will occur. (*d*) Fruit must not be piled over 12 inches deep. (*e*) Fruit must not be picked when wet or during wet weather. (*f*) Fruit must not suffer from prolonged exposure to the sun. (*g*) Fruit should be fully mature before being picked and of a degree of ripeness that by the time they reach the consumer they are fully ripe and of a pale lemon yellow colour.

(*b*) *Lemons.*—The same care in handling, prevention of damage, and mechanical injury is required as with grape fruit but the fruit must be picked in a green or semi-ripe condition and artificially coloured. At Aburi the fruits do not ripen uniformly and attain a good colour if left on the trees and it is safe to assume that they would not do so when grown on a large scale in other parts of the Colony. Artificial ripening also allows fruits to be picked when of uniform size, stored for several months and placed on the market when prices are most favourable.

GRADING AND PACKING

(a) *Grape Fruit.*—Cases recommended are of the same type as those used in South Africa, the inside measurement being, length 23 inches, breadth 11½ inches, depth 11½ inches with a central division across the breadth. These could be manufactured locally providing suitable timber was available or shipped out in shooks made of Swedish white wood. The use of standard cases is essential.

Fruit must be entirely free from surface marking of any description and each fruit must be wrapped in tissue paper. Cases should be packed to counts of 64, 70, 80 and 96 fruits and stencilled accordingly. The fruits should be firmly packed but not so tight as to cause the wood of the case to cut into the fruit.

(b) *Lemons.*—Standard cases should be used, each fruit separately wrapped in tissue paper and packed to a count of 300 per crate, the same general care being required as for grape fruit.

Artificial colouring may be effected by exposing the green fruit to carbon dioxide and carbon monoxide gas in a humid atmosphere of 90.° The process occupies about six days.

The following method in use in New South Wales is taken from a description of the process adopted by the Department of Agriculture in that country.

The actual operation was conducted thus:

The fruit just picked into "lug" boxes was stacked on pieces of wood battens resting on an earth floor. The head of boxes was then covered with a heavy canvas cover, thus enclosing the stack of fruit in practically an airtight condition. An oil engine of 2 P.H. attached to a motor spray machine was used from which the exhaust gases were conducted by a pipe sufficiently long to prevent the temperature of the fruit rising above 75°F. (piping 12 feet long was necessary).

The engine was run intermittently for five days. The actual engine running time was 61 hours, but probably the colouring could be accomplished with less engine running. The cost of oil and benzine for each experiment was 15s. 8d., and up to 97 bushels of fruit were treated at one time. It is believed that the exhaust gases were ample for treating at least three times that quantity of fruit.

In addition to keeping the temperature around 75° it is important to maintain a humidity of not less than 80%.This was accomplished by spraying water on to the ground beneath the boxes when humidity showed a declining tendency.

SHIPMENT

The Gold Coast is in direct shipping communication with England, the voyage taking 13 days.

With careful handling and packing, it is not essential that grape fruit and lemons for the English market should be refrigerated in transit. Messrs. Elder Dempster's steamers have cool room stowage available which it would be necessary to use if other stowage was not available. With a progressive firm like Messrs. Elder Dempster & Co., however, it is fairly safe to assume that shipping difficulties, should they arise, would be solved even to the extent of running special steamers if and when the industry should warrant such provision.

MARKETING

The geographical position of the Gold Coast is such as to make it compare favourably with other Colonies interested in citrus culture, since its only competitor of any importance at present would be South Africa, whose fruits take practically a week longer to reach the market than would fruit from the Gold Coast. It must, however, be remembered, that Sierra Leone are very seriously considering the citrus fruit market and in the case of this trade developing they will be able to get their fruit over in three or four days' less time.

Detailed arrangements as to marketing the fruit would have to be made beforehand with wholesale fruit salesmen such as Messrs. Broome and Green, Messrs. J. and H. Godwin & Co., or other prominent firms. It would be advisable to mark on each crate, before shipment the nature of the contents and number of fruit per case.

COSTS

(a) *From Seedling to Bearing Trees.*—Assuming 20 acres of land is planted to commence with, the cost of bringing the plantation into bearing would approximate to the following:

	£	s.	d.
Cost of trees	35	0	0
Clearing	150	0	0
Planting	3	0	0
Pruning, etc.	5	0	0
Treating diseases	5	0	0
Cutlassing, weeding	250	0	0
Mulching, etc.	50	0	0
	£498	0	0

The cost of bringing an acre of grape fruit to the bearing stage should not cost more than £25 per acre in this country. In the case of lemons this cost would be slightly greater on account of the extra number of trees required and a greater expenditure on pruning. This should not, however, exceed £30 per acre.

(b) *Maintenance Costs after Maturity per acre per Annum:*

	Grape Fruit			Lemons		
	£	s.	d.	£	s.	d.
Pruning ...	1	0	0	2	0	0
Cultivation ...	3	0	0	3	0	0
Treating, diseases, etc. ...	1	10	0	1	10	0
Fertilisers ...	6	0	0	6	0	0
Per acre per annum	£11	10	0	£12	10	0

(c) *Estimated Cost of Landing Fruit in England per Case:*

	Grape Fruit (per box of 60)			Lemons (per box of 300)		
	£	s.	d.	£	s.	d.
Cost of Production ...	0	0	6	0	0	9
Picking ...	0	0	2	0	1	0
Packing and material ...	0	0	3	0	0	5
Cases ...	0	0	6	0	0	6
Transport ...	0	0	6	0	0	6
Freight to England ...	0	3	0	0	3	0
Commission, United Kingdom charges, etc. ...	0	2	0	0	2	0
	£0	6	11	£0	8	2

A yield of 363 boxes of grape fruit, containing an average of 77 fruits should be obtained per acre and 133 boxes containing 300 fruits in the case of lemons.

WHOLESALE PRICES IN THE UNITED KINGDOM

(a) *Grape Fruit.*—An examination of the wholesale prices of grape fruit in the United Kingdom reveals very considerable fluctuations not only from one part of the year to the other, but even in any one month. There are naturally also the ordinary variations in prices on any one date due to differences in quality and picking.

As an illustration, Jamaican grape fruit may be taken. At Liverpool during the past 12 months, according to the market report of a well-known firm of fruit merchants, the price of this fruit has fluctuated between 10s. 9d. and 17s. in November, and 31s. 6d. and 46s. in September.

Another striking case is that of Florida grape fruit where quotations have varied between 12s. to 19s. 3d. and 26s. to 40s. which was obtained in May.

The highest prices were, however, obtained by Porto Rician grape fruit, the best qualities of which reached 47s. to 48s. and 44s. to 49s. in September.

South African grape fruit were available in July and August, but did not attain very high prices, ranging between 9s. 6d. and 18s. 9d. with one solitary quotation—the last of the season—of 25s.

Similar fluctuations were noted in the wholesale prices of grape fruit in London as given by a large firm of wholesale fruit merchants.

Isle of Pine grape fruit varied in price between 17s. to 25s. Florida between 19s. to 30s. 6d. and Jamaican between 12s. and 23s.

(b) *Lemons.*—No wholesale prices are available but as the retail price for good fruit is never less than 2d. and frequently much more this may be taken as varying between 20s. and 30s. per box.

ESTIMATED NETT REVENUE PER ACRE

(a) *Grape Fruit.*—With a wholesale price as low as 10s. per case, a nett profit per acre of £55 would be obtained. Even assuming the yield was only 200 fruits per tree and the wholesale price 10s. per case, a nett profit of £27 would be received. The greatest possible nett profit from an acre of cacao could not exceed £10 per acre, so it is evident grape fruit culture in this country would be a highly remunerative undertaking.

(b) *Lemons.*—The nett profit per acre from lemon trees grown on good soil and in full bearing exceed the figures quoted above and even with a yield less than half that estimated, and double the production costs, a very handsome profit would be available.

INCREASED DEMANDS IN GREAT BRITAIN FOR GRAPE FRUIT

The steady increase in the demand for grape fruit has provided the trade with one of its most interesting features of recent years, and there is every indication that the time is not far distant when grape fruit will rank with apple, orange, banana and grape as being among the most popular fruits handled by our industry. This consistent and increasing demand will undoubtedly be helped by the fact that the grape fruit furnishes yet another instance of a fruit that is available to the trade from one year's end to another, since no sooner is the crop at one source of supply exhausted than the sequence of supply is taken up by some other grape fruit producing area. American grape fruit provides the British market with the bulk of its requirements at present, and it is interesting to note that imports of American grape fruit into the United Kingdom during 1926 amounted to the record figure of 25,939 cases.

The other principal sources of supply are South Africa and British West Indies, and in each of these cases the trade has grown rapidly in the past six years, but the increase in the proportion supplied by the United States has been by far the greatest. Statistics indicate that three-fourths of the grape fruit imports now are supplied by the United States. Some of these imports, however, consist of fruits from the Isle of Pines shipped *via* New

York. Grape fruit has first appeared as a separate item in the United Kingdom Trade Statistics in 1920, when 21,974 boxes of 70 pounds each were imported. The United States that year supplied 58·3% of the total. British imports in 1927, the last year for which detailed statistics are available, amounted to 606,468 boxes, of which 74·6% was accredited to the United States.

While the bulk of the American exports is shipped during the six months February to July, exports are maintained on a substantial level throughout the year. South African and West Indian supplies in the British Market are, in a sense, complementary to each other. Thus South African grape fruit is available principally from June to September and West Indian supplies largely from December to April.

Although the consumption of grape fruit in Great Britain has grown very rapidly in recent years, the quantities consumed per head of the population are still very small, as indicated by the fact that during the past five years the *per capita* consumption of grape fruit has been only ·2 of a pound.

Imports of Grape Fruit into the United Kingdom

Year	South Africa	British West Indies	Other British Countries	U.S.A.	Other Foreign Countries	Total
1921	2,440	8,770	254	17,923	4,931	34,318
1922	10,216	8,854	—	30,689	800	50,559
1923	12,509	16,877	1,170	45,105	4,418	80,238
1924	15,768	15,787	925	93,689	4,018	130,186
1925	21,837	28,171	787	200,071	17,353	268,186
1926	20,997	43,486	2,688	239,847	25,939	332,956
1927	23,907	47,493	8,926	501,314	24,829	606,468

FACTORS AFFECTING GRAPE FRUIT INDUSTRY

During the past eight years the world's production of grape fruit has increased rapidly and a further large increase may be expected. Taking the import figures into consideration it appears to be inadvisable to carry out further expansion. The production and delivered costs must, however, be taken into consideration. The West Indies cannot land and sell grape fruit in the United Kingdom at less than 30s. 6d. per box, California and Texas 18s. per box, Florida, the Isle of Pines and Porto Rico 16s. per box. Landed costs of Gold Coast fruits should be considerably below any of these figures which places the Gold Coast produce in a distinctly advantageous position. Should the supply at any time exceed the demand the country which can produce good quality fruit at a lower price than any of its competitors is justified in continuing its existng industry or commencing one.

The factor of lower production and landing costs loses its importance unless fruit of good quality and uniformity can be produced since the public will always pay more for a high grade product irrespective of its origin.

There appears to be no reason why the Gold Coast cannot produce fruit equal to that of anywhere in the world. If it can do so, and at the same time keep production and landing costs below that of other countries, it is in a distinctly advantageous position.

THE NITROGEN INDUSTRY AND OUR FOOD SUPPLY*

FOR many centuries nitrogen was used as a fertiliser in the form of farmyard manure, and certain rotations of crops, which kept up the nitrogen in the soil, had been popular; but it was not until 1840, when Liebig first pointed out the true function of nitrogen, potash, and phosphorus, that fertilising became an art based on science. Liebig's work became widely known in a very short time. A little later Lawes and Gilbert started their experiments at Rothamsted, which definitely proved the part taken by nitrogen in agriculture.

From 1840 the use of nitrogen in the form of Chile nitrate steadily increased, and about 1880 sulphate of ammonia became available from by-product coke ovens, and by 1903 the world consumption of these two fertilisers had increased to 1,975,000 tons, equivalent to 351,000 tons of nitrogen.

In 1905 calcium cyanamide was manufactured on a commercial scale for use as a fertiliser, and in the same year the arc process for combining the oxygen and nitrogen of the air to form nitric acid was launched unsuccessfully in Canada. Two years later the arc process was established in Norway and calcium nitrate was put on the market as a fertiliser. Thus Crooke's dream of the commercial production of the nitrogenous fertilisers from the nitrogen of the air was realised in less than ten years. But it was the Haber-Bosch process for the fixation of nitrogen which was to supersede all others and make it possible for us to produce all the nitrogen fertilisers we require now and as far in the future as we can see. In 1906-9 Professor Haber investigated the chemical equilibrium between nitrogen, hydrogen, and ammonia when heated under a pressure over a catalyst. Then Dr. Bosch of the Badish Analin u. Soda Fabrik successfully manufactured ammonia on a large scale by this process in 1913 to 1914.

The fixation of nitrogen in the form of ammonia is so much cheaper than by any other process that this process has very largely replaced the cyanamide and arc processes, and it has shaken the Chile nitrate industry to its foundation—so that the Chilean Government and the nitrate manufacturers have to revise their methods and their processes.

The production of nitrogen in various forms is shown in Fig. 1. The quantities are expressed in tons of nitrogen contained in the products. It will be noticed that the nitrogen industry had already achieved considerable importance in 1898, but it was not until 1921 that the synthetic nitrogen production became greater than the Chilean nitrate production.

NITROGEN FERTILISERS

The world's consumption in 1928 of nitrogen in the form of ammonium sulphate from synthetic ammonia and by-product coke ovens, cyanamide, nitrate of lime, nitro-chalk, and ammonia liquor was 1,442,000 tons and in the form of Chile nitrate 401,000 tons, making a total of 1,843,000 tons, of which 185,000 tons are used in industry and 1,658,000 tons are consumed as fertilisers. If fixed nitrogen is worth £50 a ton—which is about its price in sulphate of ammonia today—then the value of the nitrogen used in fertilising was £83,000,000.

* By Dr. R. E. Slade in *Nature*, No. 3180, Vol. 126, October 11, 1930.

Now, in an acre of typical English arable soil we have in the top nine inches a quantity of humus containing about 2,500 lb. of nitrogen, and at certain times of the year changes take place in the soil making some of this nitrogen into nitrates, in which form it is available for absorption by the plant. The result of this is that in the spring about one per cent. of the nitrogen in the humus is present in the form of nitrate; thus we have present about 25 lb. of nitrogen available for the plant. As this available nitrogen is used up by the plant it is partly replaced by more nitrate being formed from the humus, but during the time of greatest growth there is a considerable depletion of available introgen in the soil. Owing to the continuous breaking down of the humus, the nitrogen absorbed by the plant is often more than 25 lb. besides what is washed away by rain. The supply of available nitrogen may be increased by the addition of nitrates or ammonium salts—for the latter are rapidly oxidised to nitrates in the soil.

If we spread one hundredweight of sulphate of ammonia over an acre of ground, this adds 23 lb. of nitrogen to this area, of if we consider the top nine inches of the soil over this area of an acre, we add 1 lb. of nitrogen to each 120,000 lb. of soil. This is such a small amount that we might be doubtful whether it would be sufficient to make any appreciable difference to plants grown on this area. But we have seen that this quantity is of the same order as the quantity of available nitrogen already in the soil.

We will now enquire into the magnitude of the increased yields of crops which can be obtained by the use of nitrogen fertilisers. The figures given in table 1 are average increased yields of various crops obtained on good soil for the addition of each lb. of nitrogen in a fertiliser. They are the averages over many years and many different soils, so that they are increased yields that may be expected for the addition of each lb. of nitrogen—if there is not a deficiency of potash or phosphoric acid in the soil.

Table I

Crop	Increase for 1 lb. Nitrogen	Nitrogen in Crop (per cent.)	Nitrogen Efficiency (per cent.)
	(lb.)		
Wheat (grain)	11·4	1·8	20·4
Barley (grain)	14·2	1·3	18·5
Oats (grain)	12·4	1·6	19·7
Potatoes (tubers)	94·0	0·3	28·2
Swedes (roots)	94·0	0·2	18·8
Mangolds (roots)	150·0	0·2	30·0
Hay	42·3	1·45	61·5

The nitrogen efficiency of the fertilisers in the last column is the percentage of the nitrogen in fertilisers which appears in whole or part of the crop described in the first column.

In table II the increased yields are calculated so as to show the increased crop obtained from one hundredweight of sulphate of ammonia in common units.

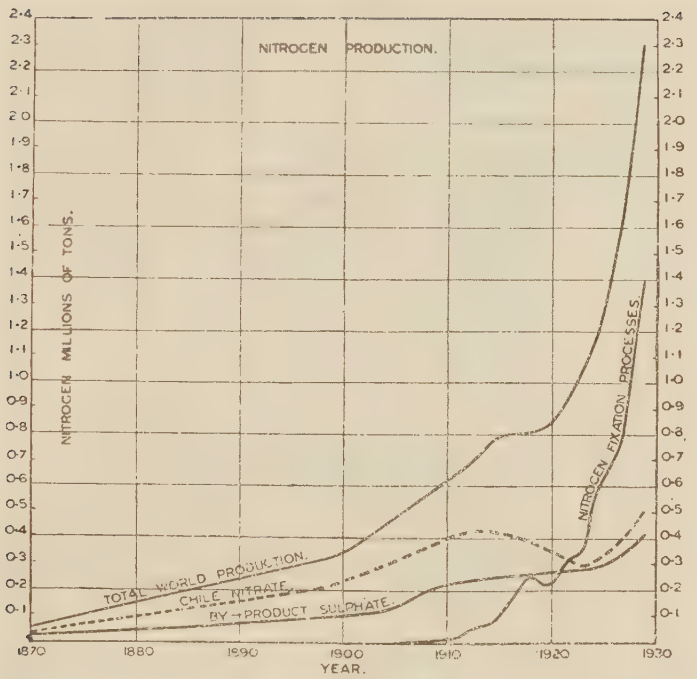
NITROGEN PRODUCTION.
NITROGEN MILLIONS OF TONS.
2·4
2·3
2·2
2·1
2·0
1·9
1·8
1·7
1·6
1·5
1·4
1·3
1·2
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
TOTAL WORLD PRODUKTION.
CHILE NITRATE.
BY-PRODUCT SULPHATE.
NITROGEN FIXATION PROCESSES.
1870
1880
1890
1900
1910
1920
1930
YEAR.

Fig. 1.

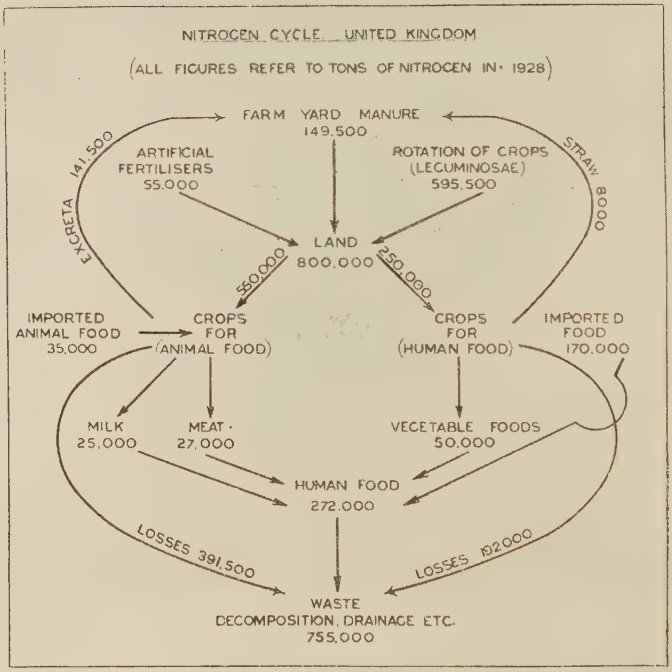
NITROGEN CYCLE. UNITED KINGDOM
(ALL FIGURES REFER TO TONS OF NITROGEN IN 1928)
FARM YARD MANURE
149,500
ARTIFICIAL
FERTILISERS
55,000
ROTATION OF CROPS
(LEGUMINOSAE)
595,500
EXCRETA 141,500
STRAW 8000
LAND
800,000
550,000
250,000
IMPORTED
ANIMAL FOOD
35,000
CROPS
FOR
(ANIMAL FOOD)
CROPS
FOR
(HUMAN FOOD)
IMPORTED
FOOD
170,000
MILK
25,000
MEAT
27,000
VEGETABLE FOODS
50,000
HUMAN FOOD
272,000
LOSSES 391,500
LOSSES 192,000
WASTE
DECOMPOSITION, DRAINAGE ETC.
755,000

Fig. 2.

Table II

Crop	Increase for 1 cwt. of Sulphate of Ammonia.
Wheat ...	4·5 bushels or 2·41 cwt.
Barley ...	6·5 ,, ,, 3·02 ,,
Oats ...	7·0 ,, ,, 2·62 ,,
Potatoes ...	20·0 ,,
Swedes ...	20·0 ,,
Mangolds ...	32·0 ,,
Hay ...	9·0 ,,

If we feed grass to a cow giving two gallons of milk a day, we find that 1 lb. of nitrogen causes sufficient extra grass to grow to keep the cow alive one day and to give two gallons of milk. Since two gallons of milk contain 0·8 lb. of proteins or 0·128 lb. of nitrogen, we have 12·8 per cent. of the nitrogen of the fertilisers appearing in the milk, or the efficiency with which the fertiliser is used *via* grass to make milk is 12·8 per cent.

The efficiency of meat production is lower, one pound of nitrogen fertiliser only producing 0·05 lb. of nitrogen in beef, or an efficiency of 5 per cent. on fertiliser.

Summing up these nitrogen efficiencies we have:

Fertiliser to grain	about 20 per cent.
,, ,, potatoes	,, 30 ,, ,,
,, ,, grass or hay	,, 60 ,, ,,
,, ,, milk	,, 12·7 per cent.
,, ,, beef	,, 5 ,, ,, or lower.

It is not surprising that grass shows a higher efficiency than other crops, because the roots cover the ground more completely. I think that the efficiencies on the whole are very high; compare the energy efficiency of a high-class locomotive on the railways, which is not more than 8 per cent.

FOOD PRODUCTION

The food of a man in Great Britain is approximately:

Meat, fish	14·5 per cent.
Cereals	18·5 ,, ,,
Milk, cheese, etc.	24·5 ,, ,,
Potatoes and roots	25·8 ,, ,,
Sugar, fruit, etc.	15·5 ,, ,,

—and the nitrogen efficiency in growing these foods from fertilisers is probably about 17 per cent.

The amount of protein consumed per head is 86·5 gm. per day; this contains 14 gm. of nitrogen, so that if this food were grown by using fertilisers at an efficiency of 17 per cent. we should require to use 82 gm. of nitrogen in fertilisers to produce the food for one person for one day; or the fertiliser required to feed one person for a year must contain 365 × 80 gm., of 29 kgm. of nitrogen. One ton of nitrogen in the form of sulphate of ammonia or nitrate of soda will therefore produce enough food for 34 people for one year.

Since the total amount of nitrogen consumed in fertilisers during 1928 was 1,658,000 tons, the amount of extra food produced from this fertiliser would contain enough nitrogen in the form of proteins to support 56,000,000 people; and there would be sufficient carbohydrates and fat associated with this protein to form a complete diet.

Sir Daniel Hall has shown that 2-2½ acres of land are required under cultivation to feed one person. Let us compare this with 1/34 tons of fixed nitrogen. If we assume that the total capital required to build a nitrogen factory is £70-£100 per ton year of nitrogen, inclusive of everything, then for a maximum of £3 invested we can support one person. It would be impossible to bring 2-2½ acres of land under cultivation at so low a capital cost. I do not think that land can usually be settled and cultivated at a less capital cost than £10 per acre, including roads and railways, houses, and agricultural machinery, so that to bring two and a half acres under cultivation would need £25 capital as compared with £3 necessary to produce the fertiliser to produce the same amount of food. I would particularly like to direct attention to this calculation in some countries where governments are always ready to consider and finance schemes to build railways and roads to open up new country or to build irrigation schemes, although the capital to be invested for a given amount of food-producing capacity is often enormous.

STABILITY OF THE NITROGEN FIXATION INDUSTRY

In fixing one ton of nitrogen and making it into fertilisers we use for all purposes about five and a half tons of coal, so that to provide the fertiliser to feed one person for a year we require 3¼ cwt. of coal. The population of the world (excluding China and Turkey) is now about 1940 millions, and 56 millions or 2·8 per cent. are now being fed with food grown by nitrogen fertilisers. Of the nitrogen fertilisers consumed in the year 1928, about 1,000,000 tons of nitrogen was produced by synthesis, needing 5·5 million tons of coal. This quantity of coal is almost negligible when compared with 1500 million tons mined every year. The rest of the nitrogen was produced by by-product coke ovens or as nitrate of soda from Chile.

The population of the world increased by 10 millions each year from 1913-1928. If we had to feed this increase of population by increased nitrogen fertilisation, we should have to build each year a works which would fix 300,000 tons of nitrogen per year and would cost upwards of £30,000,000. In order to run the works we should require 1·6 million tons of coal per year. If we built a works of this size every year for a hundred years, we should then be consuming 160 million tons of coal a year for nitrogen fixation, or only ten per cent. of the coal which is being used in the world today. At least two-thirds of the coal consumed in the fixation of nitrogen is used for power production, so we could reduce the coal required to one-third the value mentioned if other sources of power were available. There are still large areas of the world suitable for cultivation It is therefore improbable that all the food requirements for the growing population of the world will have to be supplied exclusively from nitrogenous fertilisers for some time to come.

DISTRIBUTION OF NITROGEN FERTILISER

Let us now investigate the use which the world makes of the nitrogenous fertilisers available at the present time. I have already mentioned that of the 1,843,000 tons of nitrogen consumed in 1928, 1,658,000 tons or 90 per cent. was used in agriculture.

In table III are shown the quantities of nitrogen consumed in the different countries during the year 1928.

How much atmospheric nitrogen is combined by electric discharges ? How much by bacteria ? How much by our synthetic ammonia processes ? How much humus changes to give nitrate ? How much nitrate is washed away and how much goes into the crop ?

Table III

	Nitrogen consumed		
	Metric tons, 1928		Lb./Acre Arable
Germany ...	615,200	...	22·3
France ...	166,900	...	6·7
Belgium ...	63,600	...	45·9
Czechoslovakia ...	33,800	...	5·0
Denmark ...	29,100	...	9·8
Holland ...	73,400	...	70·6
Italy ...	68,300	...	4·7
Poland ...	54,600	...	2·7
Spain ...	67,300	...	3·8
Great Britain ...	61,600	...	10·4
Total (Europe)	1,134,800	...	—
U. S. A. ...	383,600	...	2·4
Japan ...	113,300	...	16·8
Egypt ...	35,900	...	9·2
Other countries ...	175,600	...	—
Total (World)	1,843,200	...	—

What happens to that going into the crop and how much of it forms humus ? What happens to the dissolved nitrogen going down the river into the sea ? How much comes back to land in the form of fish ? Again, how much nitrogen is liberated again from combination ? Is there a dynamic equilibrium in this nitrogen cycle—or are we drifting in one direction ? Are we gaining nitrogen in the air or are we losing it ?

We cannot get answers to these questions. There is no doubt that, in the past, nitrogen was stored up in coal and in Chile nitrate, and this is being liberated now, but we do not know whether nitrogen is being stored up anywhere at the present time. In the diagram, Fig. 2. I have made an estimate of the principal movements in the nitrogen cycle of Great Britain for the year 1928.

The vegetable foodstuffs consumed by man are estimated to contain 50,000 tons of nitrogen. If these are grown with a nitrogen efficiency of 20 per cent. then 250,000 tons of nitrogen is required in the soil. Of this nitrogen it is assumed that 50,000 tons go into vegetable food, 8,000 tons into straw which form farmyard manure, and the rest, 192,000 tons, are washed out of the ground by rain water and lost to the rivers and seas. It will be noticed that I have assumed that the wastage of nitrogen derived from humus is the same as the wastage of nitrogen from artificial fertilisers. I have no direct evidence for this—I have no evidence at all; I cannot think of a more reasonable assumption. I have taken no account of the vegetable and animal life on the moors and mountains except so far as it provides human food. Probably I have neglected some other important factors, but I make no apology for offering this first attempt at a nitrogen flow sheet for Great Britain.

We are now getting much better statistics of agricultural production than formerly, and I believe that consideration of these statistics with other statistics now available has opened up new fields of study in agricultural economics. I have calculated the average amount of nitrogen obtained from

an acre of crops in different countries. The figures in table IV, are for the year 1928. They were obtained by calculating the weight of nitrogen in each crop for each country and then adding up the total amount of nitrogen for each country. This weight of nitrogen is then divided by the area on which the crops grew and we get the weight of nitrogen in the crop in lb. per acre average over the whole country. By crop we mean the portion of the crop taken away for consumption by man or animals : for example, of wheat the grain, of potatoes the tubers etc. The rest of the crop usually goes back to the land and is considered as part of the agricultural system of the country.

Since some crops give a larger yield of nitrogen, in the useful part of the crop, than others, the figures in the table are to some extent affected by the different crops and different proportions of each crop grown in the country. But so far as I can see, the effect of the different crops grown is of only minor importance, and as the production of proteins is the farmer's business, we are not far wrong in considering the first column as an index of the agricultural efficiency of that part of the country under

Table IV

Year 1928	lb. per acre.		
Country	Total Nitrogen in crops	Nitrogen in crops from Artificial Fertilisers	Nitrogen in crops from Humus
Denmark	52·0	2·4	49·6
Holland	49·0	17·6	31·4
Belgium	47·2	11·5	35·7
Great Britain	40·2	2·6	37·6
Japan	34·2	4·2	30·0
Germany	32·5	5·6	26·9
Egypt	31·6	2·3	29·3
France	23·5	1·7	21·8
Canada	21·8	0·1	21·7
U.S.A.	20·8	0·6	20·2
Italy	20·5	1·2	19·3

crops. In the second column is given that part of the nitrogen in the crop which has been supplied by artificial fertilisers. It is assumed that on an average 25 per cent. of the nitrogen supplied to the land as fertiliser is found in the useful portion of the crop. The third column is the difference between the other two columns and is the weight of nitrogen in the crop which has been supplied by the land. In countries with a good system of farming and a good rotation of crops this quantity is high. We see that the system of agriculture in Denmark produces more than twice as much as that in Canada, U.S.A., and Italy, and that in Great Britain we are a little better than Belgium and considerably better than Holland in our agricultural system, apart from the use of artificial nitrogen fertilisers. But since Holland uses seven times and Belgium four times as much nitrogen fertiliser per acre, these two countries obtain greater crops than those obtained in Great Britain, as is shown in the first column.

In Holland one-third of the crops appear to be grown from nitrogen fertilisers. There seems to be no climatic or other physical reason why fertilisers should not be used to a greater extent in Great Britain. If we used as much per acre as in Holland, we should consume 420,000 tons of nitrogen per year; if as much as in Belgium, 272,000 tons; and if as much as in Germany, 132,000 tons. The reason that we de not use more fertilisers does not appear to be economic. The use of sulphate of ammonia yields 100 to 300 per cent. on the money invested within a year. Consider the special case of the fertilisation of wheat. For some years the price of wheat and of sulphate of ammonia has been practically equal. Since 1 cwt. of sulphate of ammonia gives an increased yield of wheat of 2·4 cwt. even after paying for phosphatic and potash fertilisers, one hundred per cent. will be earned on money spent on nitrogen.

Development of the nitrogen fixation industry has lowered the price of nitrogen fertilisers, so that we can expect the needs of the increasing population of the world to be met first by more intensive cultivation of land close to the markets for food rather than by extension of the cultivated area.

MANURIAL EXPERIMENTS ON HEVEA*

IN a previous paper† the results of various manuring experiments on the estates of the Hollandsch Amerikannsche Plantage Mij. were described. One of these experiments there called the "Second Nitrate Manuring Experiments" has been continued and three years' additional results are now available as shown in table 1. The results given by years are discussed below:

Sixth year, March 1924-February 1925.—On March 17th, 1924 the tapping system of the experiment was changed from one-third of the circumference tapped daily to one-half of the circumference tapped in alternate months, the bark consumption being increased from $1\frac{3}{4}$ per month to 2 in. per tapping month. The tapping cut was lengthened by extension in a downward direction. The renewal period remained at 6 years. As will be seen from the yields in table 1. no falling off in yield resulted from this change.

The C. plots received the usual annual applications of 5 lb. sodium nitrate per tree and reached a yield of 535 lb. per acre for the year, the highest reached up to that time.

The B. plots which had been five years without manuring and which as noted in the previous year were showing signs of deterioration again, were used for testing a new nitrogen manure, "Ammophos" applied at the rate of 5 lb. per tree in March. The grade of "Ammophos" used was the 20-20 *i.e.* 20% ammonia and 20% phosphoric acid (P_2O_5). This form of "Ammophos" contains ammonium sulphate as well as ammonium phosphate. Although a slight improvement in the colour of the foliage was discernible no effect in the yield was noted and the results could not compare with the effect of ammonium sulphate.

The E. plots received their normal biennial application of ammonium sulphate, the quantity this year for the first time being reduced to 4 lb. per tree giving an amount of nitrogen equivalent to 5 lb. of sodium nitrate.

The D. plots received no treatment.

Seventh year, March 1925-February 1926.—The C. plots annually manured with sodium nitrate again reached a new high record yield of 550 lb. per acre. The control A. plots showed a slight rise of 13 lb. per acre due probably to an average lower tapping cut than the previous year. The deterioration in appearance of these plots continued.

The B. and E. plots were not manured.

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* By J. Grantham, *Archief voor de Rubbercultuur,* Jaargang 11, No. 10, October 1927.

† Manurial Experiments on Hevea, *Archief voor de Rubberculturr,* VIII Jaargang, No. 8, August 1924. (Summary published in *The Tropical Agriculturist,* Vol. LXIII, No. 5, November 1924).

Table I

Series	Treatment in 1924	1924 March 1 to 15	1924 March 17-April 15	1924 May 17-June 15	1924 July 17-Aug. 15	1924 Sept. 17-Oct. 15	1924 Nov. 17-Dec. 15	1925 Jan. 17-Feb. 15	Total March 1924-Feb. 1925	lb. per acre per year	Kg. per H. A per year
A	Control	32·9 100	112·8 100	223·5 100	300·0 100	276·2 100	307·8 100	278·4 100	1532·5 100	255	286
B	5 lb. 20·20 Ammophos per tree—March	58·8 178·7	203·3 180·2	307·4 137·5	401·3 133·8	363·5 131·8	393·0 127·3	350·8 126·1	2078·1 135·6	346	388
C	5 lb. sodium nitrate per tree—March	115·9 352·3	358·6 317·9	472·1 211·2	588·4 196·1	530·0 191·1	585·2 189·6	561·9 201·8	3212·1 209·8	535	600
D	None	51·5 156·5	169·0 149·8	333·7 149·3	429·8 143·3	393·1 142·3	440·7 142·8	393·2 141·2	2211·0 144·3	368	412
E	4 lb. ammonium sulphate per tree—March	89·1 270·8	294·6 261·1	422·2 189·8	514·2 171·4	479·1 173·4	522·0 169·1	477·9 171·7	2799·0 182·0	466	522

Series	Treatment in 1925	1925 March 17-April 15	1925 May 17-June 15	1925 July 17-Aug. 15	1925 Sept. 17-Oct. 15	1925 Nov. 17-Dec. 15	1926 Jan. 17-Feb. 15	Total March 1925-Feb. 1926	Lb. per acre per year	Kg. per H. A. per year
A	Control	229·6 100	222·8 100	314·1 100	271·7 100	306·3 100	262·6 100	1607·1 100	268	300
B	None	312·6 136·1	319·2 143·3	418·6 133·3	361·2 132·9	372·3 121·5	351·2 133·7	2135·1 132·9	356	398
C	5 lb. nitrate of soda per tree—February	585·9 255·2	516·0 231·6	599·0 190·7	527·0 194·0	540·5 176·5	532·5 202·8	3500·9 205·4	550	616
D	2 lb. ammonium sulphate per tree—February	386·6 168·3	329·4 147·8	435·0 138·5	395·0 145·4	404·8 132·2	402·5 153·3	2353·3 146·4	392	439
E	None	433·2 188·7	425·7 191·0	548·3 174·5	470·5 173·2	493·7 161·2	467·1 177·9	2838·5 176·6	473	530

Series	Treatment in 1926	1926 March 17-April 15	1926 May 17-June 15	1926 July 17-Aug. 15	1926 Sept. 17-Oct. 15	1926 Nov. 17-Dec. 15	1927 Jan. 17-Feb. 15	Total March 1926-Feb. 1927	lb. per acre per year	Kg. per H. A. per year
A	Control	175·6 100	237·5 100	291·2 100	274·7 100	301·0 100	270·4 100	1550·4 100	258	289
B	4 lb. ammonium sulphate per tree—February	272·6 155·2	311·5 131·2	385·2 132·3	360·8 131·3	416·9 138·5	378·6 140·0	2125·6 137·1	354	397
C	5 lb. nitrate of soda per tree—February	463·7 264·1	538·9 226·9	636·0 218·4	571·8 208·2	654·2 217·3	618·4 228·7	3483·0 224·7	580	650
D	None	316·5 180·2	376·4 158·5	433·0 148·7	394·3 143·5	426·7 141·8	406·8 150·4	2353·7 151·8	392	440
E	4 lb. ammonium sulphate per tree—February	390·6 222·4	469·8 197·8	559·2 192·0	510·6 185·9	570·7 189·6	531·6 196·6	3032·5 195·6	505	566

N.B.—All yields given are 1st. latex plus lump only, scrap rubber not being included.

The D. plots previously used for calcium nitrate applications in alternate years, received 2 lb. of ammonium sulphate per tree, *i.e.*, half normal quantity, to be applied in alternate years in future, calcium nitrate beig no longer considered a suitable manure owing to its very hygroscopic nature and destructive action on the skin of the coolies handling it.

No residual effect of the "Ammophos" applied the year previously, appeared in the B plots, the increase in yield being inappreciable.

Eighth year, March 1926-February 1927.—Yet again the annually manured C. plots reached a new high record of 580 lb. per acre and this in spite of an average higher tapping cut, which was expected to cause some falling off in yield. Apparently the limit of increase in yield from nitrogen manuring is not yet reached in these plots.

The control A. plots continued to deteriorate in appearance, severe die-back of the main trunk being quite advanced in a large number of trees particularly in the centre of the plots. From the generally better appearance of the trees on the borders of the plots there is reason to believe that roots passing beneath the isolating drains secure some benefit from the manuring in adjacent plots. The effect is not one of the drains themselves since there are drains through the centres of the plots.

No effect having been shown by the "Ammophos" manuring, the B. series of plots received 4 lb. ammonium sulphate per tree and it is the intention in future to repeat this application annually.

The E. plots received their biennial application of 4 lb. of ammonium sulphate and gave a record yield for this series of 505 lb. per acre for the year.

All plots are now on a permanent manuring scheme which will be continued unmodified for a long period of years as summarised below:

A. Control = unmanured.

B. Annual manuring with ammonium sulphate 4 lb. per tree.

C. Annual manuring with sodium nitrate 5 lb. per tree.

D. Biennial manuring with ammonium sulphate 2 lb. per tree, (half normal quantity).

E. Biennial manuring with ammonium sulphate 4 lb. per tree.

It will of course be a few years before series B. and D. will be comparable with the other series, which have remained unchanged since the beginning of the experiment.

The results so far obtained have been considerably in excess of those originally anticipated and the response of white soil to nitrogen manuring is so favourable as to neutralise the natural superiority of the red ground.

As an example of the realization on a large scale of the increased yields indicated by the experiments it may be mentioned that the yield of the H.A.P.M. over an area exceeding 40,000 acres, of which about 85% is white soil, having reached a standstill at just below 300 lb. per acre in 1920 and commenced to fall back in 1921, showed a steady increase to 474 lb. an acre for the year 1926, following an expanding manurial program on the white soil during the years 1921 and 1923-1926.

Ammonium Sulphate (Time of Application) Experiment Soengei Baleh 1.—Ammonium sulphate was applied at fortnightly intervals from the beginning of December 1922 to the end of January 1923, to alternate fields in an area previously unmanured on Soengei Baleh Estate, with the idea of testing to what extent it was possible to apply the manure before the dry season in February, without risk of serious loss by leaching out by the heavy rains. The manure was broadcasted in the usual manner on the surface of the ground.

Alternate fields were treated with 4 lb. of ammonium sulphate per tree as shown in table II.

Table II

Field	Acres	Treatment	Yield in lb. of latex per acre	% Relation to adjoining controls
1 & 3	7·88	Ammonium sulphate—December 9, 1922.	1950	127
2 & 4	7·86	Control = Unmanured	1531	
5 & 7	7·53	Ammonium sulphate—December 17, 1922.	1669	130
6 & 8	8·32	Control = Unmanured	1268	
9 & 11	7·84	Ammonium sulphate—January 2, 1923.	1636	127
10 & 12	8·15	Control = Unmanured	1289	
13 & 15	7·76	Ammonium sulphate—January 17, 1923.	1404	113
14 & 16	8·15	Control = Unmanured	1245	
17	3·88	Ammonium sulphate—February 5, 1923	1393	119
18	4·66	Control = Unmanured	1173	
Total	34·79	Ammonium sulphate	1639	125
Total	37·20	Control = Unmanured	1309	

Equally striking results on appearance (denser dark-green foliage) within 2 to 3 months after wintering were obtained on all manured plots, even those on which heavy rain took place with 48 hours of the period of application. Some retardation of wintering occurred in all manured plots but was most pronounced in the later manured ones.

Records kept of the latex weight of the fields before the experiment started showed the yields to be reasonably uniform. The total yields on alternate month tapping on a half cut from March 1923 (the wintering period for which the application was made) to December 1924 are given in table II.

The experiment is from its nature not a very precise one as regards comparison of yields and no fine distinctions can be drawn between the various times of application, but it will be noted that the average increased yield of all plots over the controls is 25% for the 22 months of the experiment, and that the longest application before wintering, viz. the December 9th. application, gave 27% increase.

The effect of the ammonium sulphate is apparent on all plots and the conclusion is reached, that ammonium sulphate may be supplied a month or two before wintering without appreciable loss, and that the earliest application is at least as good as the latest.

Ammophos Experiment—Soengei Baleh 1.—In addition to the test with "20-20 Ammophos" carried out in the B. plots of the "Second Nitrate Manuring Experiment," a test was also made on a much larger scale in an area of 58 fields previously unmanured on Soengei Baleh Estate, on the opposite side of the road from the Experiment on the time of application of ammonium sulphate just described, 29 alternate fields were manured in the wintering period of March 1924 with 5 lb. per tree of ammophos, the other 29 fields being left unmanured as controls.

A very slight effect in the colour of the foliage was noted about 2 months after the application but as shown in table III, absolutely no effect was produced in the yield in contrast to the much darker colour and increased yields given by the ammonium sulphate on the either side of the road, the previous year.

Table III

Month		Average lb. of latex per acre		Per cent. relationship manured to unmanured
		29 manured fields Total 117 acres	29 manured fields Total 115 acres	
March-April	1924.	75·2	74·6	101
May-June	,,	115·2	116·6	99
July-August	,,	149·8	152·9	98
September-October	,,	119·9	122·1	98
November-December	,,	163·6	160·8	102
January-February	1925.	165·2	169·5	98
March-April	,,	138·8	143·6	97
May-June	,,	114·2	118·7	96
July-August	,,	163·9	168·8	97
September-October	,,	158·8	165·9	96
November-December	,,	143·0	147·4	97
Total	...	1,507·6	1540·9	98

It is not clear why "20-20 Ammophos" should have given no results, while ammonium sulphate on the adjoining land applied the previous year gave quite definite results.

In describing "20-20 Ammophos" the makers state that it differs from the 13-48 grade (which is almost entirely monoammonium phosphate) in being made with sulphuric acid in place of part of the phosphoric acid. An analysis showed a composition approximately equivalent to a mixture containing a molecule of ammonium sulphate $(NH_4)_2SO_4$ to each molecule of monoammonium phosphate $NH_4H_2PO_4$. Two-thirds of the nitrogen therefore appears to be in the form of ammonium sulphate. The 20-20 Ammophos is however more acid ($_pH = 4·5$) than the ordinary ammonium sulphate alone ($_pH = 5·0$) and possibly this exercises a prejudicial effect as was the case with calcium superphosphate in the D. plots of the "Second Nitrate Experiment" in 1920.

SUMMARY

1. The continued results of manuring with nitrogen fertilizers obtained in an experiment on Soengei Baleh Estate are given for the 6th., 7th., and 8th. years. The plots manured annually in the wintering period with sodium nitrate have reached a yield of 580 lb. per acre or 650 Kg. per H.A. for the year 1926-27 against a yield from the control unmanured plots of only 258 lbs. per acre or 289 Kg. per H.A. The plots manured once in two years with ammonium sulphate have reached a yield of 505 lb. per acre or 566 Kg. per H.A. The tendency of the yield of the manured plots is still upward.
2. It was shown that ammonium sulphate could be applied without loss in effectiveness up to 2 months before the commencement of the wintering period, even where heavy rain occurred soon after the application.
3. No increase in yield was obtained by the use of the fertilizer "Ammophos" grade 20-20 *i.e.* 20% ammonia (NH_3) and 20% phosphoric acid (P_2O_5).

THE SMOKE-HOUSE FOR RUBBER*

"DEVON" TYPE MUCH THE MOST EFFICIENT

A comparison of the relative efficiency of various types of smoke-houses for the curing of rubber has recently been carried out by the Rubber Research Institute of Malaya, and the results are reported by Mr. R. G. Fullerton in the Quarterly Journal of the Institute (Vol. II, No. 2). Statistical data was obtained by circulating a questionnaire among some fifty estates in various parts of the country. The estates responded by sending particulars of 12 "Devon" smoke-houses, 17 of the "Third Mile" type, and 32 of miscellaneous design.

The mean monthly output of rubber per cubic foot of drying space was found to be: "Devon" type, 6·7 lb.; "Third Mile" type, 3·8 lb.; and Miscellaneous types, 2·9 lb.

It must be pointed out that among those houses classed as miscellaneous are a few giving higher figures for efficiency than the mean value of the "Third Mile" type, although none are higher than the mean value of the "Devon" type. This means that "Devon" houses take precedence over all the others examined, but one is not justified in saying that those of "Third Mile" design are second in order of merit, for the classification of the others under one head does not imply that they all conform to a standard design.

Reasons for "Devon" Type Superiority.—The higher output of "Devon" smoke-houses depends on several factors. In the first place smoke-curing is here a continuous process since the fires are not closed down during the time that freshly machined sheets are being hung in the smoke-house and the dry rubber removed. Any rack may easily be wheeled to the outside verandah for inspection, and for emptying and filling operations, without disturbing the continuity of smoke-curing in the rest of the building, whereas in all other cases the fires must be "damped" or extinguished in order that the coolies may enter the building. The total period of curing for the "Devon" house is therefore less. Again, practically the whole of the drying space is occupied by racks carrying the rubber, and hence a greater weight of drying space than in other cases. Furthermore, the dimensions of the building are such that efficient ventilation is easily attained, for the building is tall, the height being somewhat greater than the length or breadth, no account of course being taken in this consideration of the dimensions of the verandahs, which are external to the house.

Fuel Consumption.—The figures for fuel consumption vary very considerably, the average being 1·6 lb. of fuel per 1 lb. of dry rubber. From the data collected, it was not possible to grade the various types of fire-chambers according to their economy in fuel consumption. In order to obtain fairly comparable results, one would have to test various types of fire-chambers in the same smoke-house working as nearly as possible under the same conditions, and of course no great advantage would accrue from such an experiment, since it is obvious that all that is required of the heating unit is that it shall work with the slowest combustion of the fuel which is consistent with the maintenance of the desired temperature of drying. Slow combustion of the fuel involves the

* From *The India-Rubber Journal*, Vol. LXXX, No. 14, October 1930.

production of more smoke than when combustion is rapid. From this point of view, therefore, one type of fire-chamber is as good as another provided the ventilation is adjusted so as to give the optimum conditions, and this is a matter which must be decided by experience of the operator for the individual smoke-house.

Period of Curing.—The average period of smoke-curing was found to be 10½ days. Here again there is considerable variation in the figures, and again a large number of factors are responsible. Within the limits of thickness observed (1·8 to 3·7 mm). there is no relation between thickness of the sheet and rate of curing, nor are variations in the depth of colour of the product responsible to any considerable extent.

Among the more important factors responsible for the variation may be mentioned the following:

(a) Ventilation depending on the design of the building.

(b) Temperature of drying—although in the present investigation the limits of temperature reported are practically the same in each case.

(c) Time occupied daily in filling the house with the fresh crop and removing dry rubber.

(d) Closeness of packing of the sheets in the smoke-house.

As regards factor (d) theoretically an increase in the closeness of packing of the sheets in the house tends to increse the period required for drying since the atmosphere inside the building is more moist. However, in practice the closeness of packing is not so great as to affect the rate of drying since the weight of rubber per cubic foot of space is highest for the "Devon" smoke-house, yet the rate of drying is also high. That is to say, the closeness of packing of the sheets would have to be very great indeed in order to produce an appreciable decrease in the rate of drying.

Other Points.—In the majority of cases exit for the damp air and smoke is provided at the top of the building by means of a jack-roof. The walls are of timber and the roof of corrugated iron or tiles. Rubber wood obtained by felling trees in the course of thinning out is the principal fuel employed. To a less extent a mixture of rubber and jungle wood is used. In almost all cases registration of the temperature inside the buiding is obtained by means of a maximum-and-minimum thermometer.

Discussion of Results.—Discussing the results, Mr. Fullerton says it has been made clear that "Devon" type of smoke-house proved to be the most efficient of all those examined. Houses of such design are well known, and are described in detail by Morgan ("The Preparation of Plantation Rubber," by Morgan and Stevens). The special feature of the "Devon" type of building, as has already been pointed out, lies in the provision which is made for wheeling with ease from the drying-chambers any of the racks holding the sheets outside on to a verandah without affecting the continuity of the smoke-curing of the sheets in the rest of the building. There is thus no necessity to stop firing during filling and emptying operations, which may be caried out with ease, ample space being provided on the verandah. The installation may consist of a single house with verandah or of two houses accommodated under one roof with common verandah. It is a system which lends itself very easily to expansion, and is such that it can be used to deal with a crop of almost any size. It may be mentioned that the name merely indicates the design of the house and does not specify the material of the walls or roof, or the type of fire-chamber.

The "Third Mile" smoke-house, consists essentially of a building having two storeys for accommodation of the rubber and a shallow inverted pyramidal base ending on the ground in a fire-chamber, the design of which

is the chief distinguishing mark of this type. The fire-chamber itself is outside the building and consists of an iron cylindrical drums set horizontally in brickwork. At one end of the drum is a hinged door for stoking provided with adjustable air-inlets and at the other end a door for removal of the ash. The drum communicates with the interior of the building by means of a short chimney provided inside with a "damper" adjustable from the outside, and immediately over the chimney is suspended an iron baffle-plate. This system of firing is easy to operate, and provided the doors fit fairly tightly the required amount of ventilation at the foot of the building is obtained by adjustment of the various air-vents.

In what follows is given a summary of features of construction *which should be common to all smoke-houses,* including the special type just discussed. They are considered under appropriate headings.

General Design.—From the point of view of efficiency of ventilation a tall building is to be preferred, the height being greater than either the length or breadth.

The height, however, is limited chiefly by the extent to which it is possible to maintain the required temperature of drying throughout the building and uniform colour of the product. If, for example, the houses were of excessive height rubber in the lower storeys could be maintained at the desired temperature, but that in the upper would probably be far below the optimum conditions. Generally speaking, the number of storeys should not exceed three, the ground floor accommodating the fire-chambers and the upper two storeys containing the sheets.

There is also the question of size of the building. On a large estate, from a consideration of the risk of damage by fire, it is suggested that it is a safer policy to work with a larger number of small units than to accommodate the whole of the crop in one large building.

Ventilation.—The ideal to aim at is the production of a slow current of warm smoke-laden air passing from the bottom to the top of the building. The current should not be too rapid, since in that case the rate of combustion of the fuel will be too great, dust would be raised from the ash formed, and the temperature of drying would be increased beyond the optimum limit. The draught should be just sufficient to carry off the moisture-laden air in the drying chambers.

Since the required degree of ventilation can be obtained only as a result of practical experiment with the invidual smoke-house, there should be sufficient provision for its adjustment. Ordinarily the construction of a smoke-house is not such as to render the lowest storey airtight, air-vents being unintentionally provided, for example, by chinks in the wall and round the edges of the doors. In order to minimise the risk of producing too great a draught, windows should not, therefore, be provided for the ground floor. Air-vents, provided with adjustable doors, which may be made to slide vertically in the apertures, should always be made at the walls. As a guide it may be said that openings are made about 6 inches square at intervals of 4 feet all round the building. If not required, the openings are kept closed, but in the majority of cases adjustment by means of such vents is a necessity. Another factor affecting ventilation at the base is the site of the building. If practicable the house should be situated on fairly level ground so that there is an open space for a considerable distance all round. When the smoke-house has to be placed on a steep gradient earth embankments should be cleared away in the immediate vicinity.

As regards ventilation at the roof, the top of the walls should fit tightly at the eaves of the roof, otherwise a counter current of air will at times be produced in the building. The contraction of a low jack-roof over the main roof ridge provides a very simple and efficient method for the exit of the damp air and smoke. Alternatively chimney ventilators may be constructed, and

if the fitting between the cap and body is sufficiently low interior swinging flaps for adjustment of the openings are not required. A ceiling should be provided protecting the whole of the racks and gangways and of such material that the condensation products of the smoke may be absorbed, thus preventing drops of tarry matter from falling on the sheets. For this purpose the ceiling is best made of wood; sacking would serve the same purpose without, however, being so permanent. One or more central openings in the ceiling, depending on the size of the building, are provided for exit of the damp air and smoke to the roof ridge.

Constructional Materials.—The object in all drying houses is to conserve the heat as much as possible within the building. In this connection it is evident that dfferent considerations enter into the choice of constructional materials in the case of smoke-houses than in the case of crepe drying-sheds. In the latter case there is no internal heating installation, the heat being supplied from an external source by the sun's rays, and hence crepe drying-sheds are constructed of a heat-conducting material such as corrugated iron.

In the case of smoke-houses constructed of corrugated iron, additional benefit it obtained from the heat of the sun during the day, but heat is rapidly dissipated outside the building during the night, when it is more difficult to ensure that the smoke-house attendant is keeping the fires going properly. Moreover the fires alone are capable of maintaining the temperature between desired limits. Hence the use of non-conducting materials such as brick, wood, or asbestos lining is recommended. The choice of constructional materials is of course, regulated largely by questions of economy, and in this connection it may be pointed out that timber soon becomes impregnated with tarry matter, the preservative properties of which confer a very long life on wooden walls, although there is then the risk of damage by fire to be considered. For the material of the roof brick tiles are very satisfactory provided thay are fitted well together so that there is no leakage so that ventilation is confined to the jack-roof or chimney ventilators on the roof ridge. For cleanliness of operation inside the building, the ground floor is best constructed of cement.

Fire-Chambers.—The construction of the fire-chambers must be such as to ensure the lowest combustion of the fuel which is consistent with sufficient smokeproduction and the maintenance of the temperture between the required limits, and it is known that the optimum temperature lies between 110° and 130° F. The choice of a fire-chamber depends, therefore, on the ease with which these conditions can be obtained.

From this point of view probably iron drums or boxes either placed in contact with the ground floor or mounted on a trolley leave least room for errors in ventilation and require least attention in smoking, provided the sides and bottom are almost closed to the air. Special openings near the base are usually unnecessary, and a door for stoking should not be made unless it fits closely round the edges. At the top is fitted a perforated iron plate or a cowl for distribution of the smoke. One or more of these boxes, depending on the size of the house, may be placed at intervals on the ground floor so as to give the most uniform distribution of heat and smoke. Greater freedom from dust in the building may be attained when the boxes are mounted on wheels for removal outside for cleaning and stoking. This type of fire-chamber is suitable for use in a house of any size, and particularly so in the case of small holdings where the building is often of a very temporary nature.

With brickwork ovens, whether stoked from the inside or outside, a hinged door must be fitted for cleaning and stoking, and there is always difficulty in obtaining a closely fitting door. If this can be obtained, however, one or more "butterfly" ventilators should be provided in the door for

provision of the required draught. Nothing elaborate is required for slow combustion fires, and they should be built essentially on the same lines as iron boxes. The hearth may be of clay so as to make the fire-chamber completely closed to the air at the botton. Obviously it is of advantage to arrange for stoking to be done from the outside of the building. Brickwork fire-chambers are, of course, more permanent than iron boxes, but it is doubtful if the additional expense involved is justified except in the case of very large and permanent buildings.

Reference has already been made to the "Third Mile" type, the chief advantage of which lies in the ease with which efficient adjustment of the ventilation may be obtained.

The use of pits sunk in the ground floor as fuel containers is not to be recommended since they provide a small surface for the radiation of heat.

Arrangement of the fire-chamber outside the building, the heat and smoke being distributed to the inside of the house by means of underground flues, is not to be recommended. Such an arrangement is very wasteful, for not only is a considerable amount of heat dissipated during the passage of the hot gases from the fire-chamber to the interior, but a certain amount of tarry matter from the smoke is condensed in the flues and smoke-curing is then much less efficient.

In the majority of cases iron baffle-plates suspended a few feet above the fire-chambers from the first floor are required for uniform distribution of the smoke within the building.

In all cases it is important to note that large fire-chambers are not desirable. The object should be rather to work with a larger number of small units than *vice versa*. Capacious fire-chambers require a bigger charge of fuel and slow combustion is not then easily attained. In small houses it is quite frequent to find that the fire-chamber is much bigger than is warranted by the size of the building.

Lastly, it may be said that the test of slow combustion in any fire-chamber is the nature of the residue after the wood has burnt. The most desirable results are obtained when there is the least ash and most charcoal, provided, of course, that the required temperature has been maintained.

MEETINGS, CONFERENCES, ETC.

COCONUT RESEARCH SCHEME (CEYLON)

BOARD OF MANAGEMENT

MINUTES of the eighth meeting of the Board, held at 11.30 a.m. on Wednesday, October 29, 1930, in the ball-room of the Grand Oriental Hotel, Colombo.

Present.—The Hon'ble Dr. Youngman, (in the chair), Mr. C. W. Bickmore, C.C.S., the Hon'ble Sir H. Marcus Fernando, the Hon'ble Mr. A. Mahadeva, Mr. N. R. Outschoorn, Mr. John A. Perera, J.P., U.P.M., the Hon'ble Mr. D. S. Senanayake, Mr. J. I. Gnanamuttu (Secretary).

Minutes.—The minutes of the meeting held on September 3, 1930, copies of which had been circulated to members, were taken as read and were confirmed and signed by the Chairman.

Provident Fund.—Mr. Bickmore stated that the Board's technical staff could not come under the proposed Public Officers Provident Fund Ordinance but that the Post Office Savings Bank certificates which might furnish a basis of a Provident Fund were expected to issue shortly. Mr. Bickmore consented to formulate a Provident Fund Scheme for the Board's employees.

Finance.—(a) The statement of receipts and expenditure for the quarter ended September 30, 1930, copies of which had been circulated, showed a credit balance at that date of Rs. 105,571·05, of which Rs. 80,000 was on fixed deposit. The statement was passed without comments.

(b) The draft estimates of income and expenditure for the year 1931, copies of which had been circulated to members, were considered in detail.

CAPITAL ACCOUNT

B.—*Acquiring and clearing jungle area for nursery work.*—The Chairman stated that, as Bandirippuwa was a fully developed estate any part of which it would be unwise to clear, experiments with selected nuts should be carried out on other land and that the Director of Research had suggested the acquisition of Crown jungle land to be cleared for the purpose. He thought that land wihin 10 miles of Bandirippuwa would be suitable. Sir Marcus Fernando enquired whether the Wariapola farm would not be suitable. The Chairman was not certain of the future of the Wariapola station and feared also that the extensive travelling between Bandirippuwa and Wariapola had to be considered. Although there was no objection to using Wariapola, he advised that for the present it would be preferable not to enter upon a programme of work there by the Board. The sum against this sub-head was increased from Rs. 1,500 to Rs. 5,000.

C.—*One senior staff bungalow.*—After discussion, it was agreed that the provision of Rs. 27,000 should be regarded as the limit of expenditure under this sub-head.

D.—*Two junior staff bungolows.*—The provision of Rs. 40,000 for bungalows for the Technological Chemist and the Geneticist was passed subject to details being furnished.

E.—*Four bungalows for scientific assistants and clerk.*—In passing a sum of Rs. 24,000 for quarters for three scientific assistants and one clerk, it was desired that the possibility of constructing two blocks of semi-detached quarters should be explored. Mr. Bickmore stated that in the experience of the Public Works Department this method resulted in no saving where the site value was not considerable.

F.—*Lines for menial staff.*—It was understood that the cooly lines proposed were for the menial staff and that the estate labour would be largely drawn from the resident village population. The provision of Rs. 1,200 was increased to Rs. 3,000 to allow of six quarters being built.

G.—*Laboratory structures.*—More details were desired of these. The rooms as indicated in the plan submitted by the Director of Research were considered to be too small. It was considered that as a tentative estimate the total cost might be Rs. 50,000, of which Rs. 30,000 was authorised to be spent in 1931.

H.—It was decided to vote Rs. 12,500 on account of equipment of Laboratory, including gas, electricity and water supply.

K.—It was decided to allot Rs. 5,000 under furniture for three staff bungalows subject to a list of the heavy furniture to be supplied first receiving the sanction of the Board.

A total expenditure of Rs. 340,056 was voted under Capital Expenditure, against receipts amounting to Rs. 350,000 (instalment of Rs. 150,000 out of the Government loan of Rs. 200,000, plus the Government Grant of Rs. 200,000.)

INCOME

Mr. Mahadeva pointed out that an expenditure in excess of the estimated income had been budgeted for. The Chairman explained that a surplus of income over expenditure amounting to Rs. 109,500 was expected at the end of December, 1930. Sir Marcus Fernando was of opinion that the Cess collections for 1931 had been underestimated, seeing that the coconut produce of the Island was bound to be exported in the usual way and that the exports might increase in 1931 as a result of the better weather conditions in the current year. It was agreed that the probable income from Cess collections should be fixed at Rs. 49,000, similar to that of 1930. The estimated total receipts would thus amount to Rs. 97,500, to meet a recurrent expenditure totaling Rs. 96,205.

By order,
J. I. GNANAMUTTU,
Secretary,
Coconut Research Scheme.

DEPARTMENTAL NOTES

PROGRESS REPORT OF THE EXPERIMENT STATION, PERADENIYA

FOR THE MONTHS OF SEPTEMBER AND OCTOBER, 1930

PLANS FOR THE REORGANISATION OF THE WORK OF THE STATION

The following provisional decisions have been made regarding the future work of the station:

(1) That the present trial of *Indigofera endecaphylla* in tea shall be continued till the end of September, 1931, and that thereafter the tea area shall be divided into two fields and plucked on commercial lines as a revenue-producing concern and for demonstration to the students of the Farm School.

Shade trees are to be planted in those plots where there are none at present. The unplanted strips dividing the present plots are to be planted up with tea.

(2) The following rubber experiments are to be continued for the periods specified:

(a) Right and Left cuts, till March 31st 1931.

(b) Change-over experiment, till its termination on March 31st, 1932.

(c) One-third resting experiment, probably till March 31st, 1932.

(d) Rejuvenation experiment, till August 31st, 1931, with the option of continuing till August 31st, 1932, if thought desirable. It is to be noted that the idea of replanting rubber in this area has been abandoned so that the experiment has virtually become a tapping to death experiment.

(e) New Avenue Rubber Manurial Experiment, until definite conclusions can be arrived at.

(f) Height of tapping on budded rubber experiment, as long as thought desirable.

(g) Experiment on influence of stock on scion, indefinitely, until results can be determined.

(h) Forking in of Vigna experiment. This experiment is suspended for a year to allow the re-establishment of an even growth of Vigna. It may or may not be resumed in modified form on April 1st, 1931.

(i) Two *vs.* three-day-tapping trial, and comparison of V cut with single cut in Hill top rubber, until December 31st, 1930.

(j) Comparison of continuous alternate day tapping with daily tapping in alternate months in the Hillside rubber until December 31st, 1930.

The above plans will free the whole of the central rubber block comprising Plots 77 to 87 and the Avenue Rubber by the end of 1932; it is proposed to eradicate the rubber and convert the area into a cattle-grazing paddock, leaving a few trees for shade. Certain portions of this area are already free and the eradication of the trees in these portions will be started as soon as a satisfactory contract can be arranged.

Plots 151 to 154 are now being tapped for a year with normal tapping prior to initiating a fresh tapping to death experiment. It has been decided that the tapping to death experiment shall be continued for 6 months only from April 1st, 1931, and that this rubber shall be eradicated after October 1st, 1931.

The above plans will entail a reduction of the area under rubber by the end of 1932 from $58\frac{3}{4}$ acres to $38\frac{1}{4}$ acres. The rubber that is left, apart from areas used for experiments detailed above, is to be tapped on commercial lines and used for demonstrations to the students of the Farm School.

(3) Two main lines of activity in cacao have been decided upon :

(a) The recording of individual yields of apparently high-yielding trees followed by propagation from such trees by budding, and the testing of the progeny of such trees on a field scale. Nine large cacao estates have been asked to co-operate in this work.

(b) An intensive campaign against diseases and pests in one block of cacao with the object of noting whether the cost of such treatment is justified by the value of the increase of crop over the other blocks where the present routine operations are to continue.

(4) It has been decided to undertake an investigation into the possibilities of increasing yields of robusta coffees by grafting from heavy bearing bushes. For this purpose 48 trees on the station have been selected and individual yield records have been kept since October 1st, 1930.

(5) It has been decided to undertake citrus cultivation on a large scale and it is proposed eventually to utilise plots 151-154 (rubber to be uprooted in 1931) and plot 155 (tea uprooted), with possible inclusion of plot 140A (rubber), and an area of waste land adjoining this plot.

(6) It has been decided to start selective breeding work with local black cattle to be eventually accommodated in the rubber area to be eradicated.

TEA

All vacancies in plots 141-149, 166, and the Half-Acre tea were supplied in August and failures were re-supplied twice in September and once in October.

A census of bushes in bearing was taken for record purposes in the plots under *Indigofera* trial.

RUBBER

The Change-over Experiment

This experiment was started on April 1st, 1926. 384 trees are utilized and these are divided into twenty-four plots of sixteen trees each. In eight of these plots the cut is changed over every six months, in eight plots once a year, while in the remaining eight plots no change-over is made until the panel is completed at the end of three years. Since during the course of the experiment the cuts are of necessity at different heights from the ground. No true comparison of yields can be made until both panels are completed at the end of six years. In the meantime bark renewal measurements are taken every two years and the second measurement was completed on October 1st, 1930.

It is not easy to devise an entirely satisfactory system of comparative measurement of bark renewal in an experiment of this kind. It is obvious that bark must be of the same age when measured but beyond this there are the alternatives of making all measurements at the same time, irrespective of the height on the tree at which the measurement must be made, or of

making the measurements at different times but at the same heights from the ground. The experiment was planned in collaboration with an officer of the Rubber Research Scheme who favoured the latter alternative on the ground that the thickness of bark increased in the lower portions of the tree. This officer's views were eventually adopted and measurements were made at different times but at the same height from the ground. The figures given below, however, suggest that there is a possibility that the fact that different periods, and therefore different sets of climatic conditions, intervene between two measurements in the different sets of plots may affect the issue. Thus, in the 1928 measurements the average thickness of the renewed cortex in the change-over-twice-yearly plots was larger than that of the other two sets, while in the 1930 measurements it is the smallest of the three.

It is possible that the comparative failure of the 1930 south-west monsoon may have influenced the rate of growth of renewed bark. As, however, the final standard of comparison must be the relative percentage between the thickness of renewed bark and of untapped bark, and as these figures are in the same order in both measurements, the point is perhaps of not such importance. The following are the results of the two measurements:

Measurements of Renewed Bark and Untapped Bark in Change-over Experiment

	Thickness of renewed cortex in m.m.		Thickness of untapped cortex in m.m.		Thickness of renewed cortex expressed as percentage of untapped cortex.	
	1928	1930	1928	1930	1928	1930
Average of no change-over plots	4·75	5·79	6·96	8·34	68·2	69·4
,, ,, change-over yearly ,,	4·37	5·64	6·77	8·80	64·5	64·5
,, ,, ,, ,, twice ,, ,,	5·44	4·88	9·18	9·08	59·2	53·7

It is to be noted that in 1930 average thickness of untapped bark in the change-over-twice-yearly plots comes out slightly lower than in 1928. It is not of course suggested that the average thickness of untapped bark has actually decreased but it is not possible to take the measurements in exactly the same place on each occasion and it is supposed that chance differences caused by unevenness in the bark must have brought about the result. It is to be noted that concurrently with this lack of increase in thickness in renewed bark there is a marked drop in the thickness of renewed bark in these plots compared with the 1928 figures, both actual and relative to the averages of the other sets of plots. It cannot be definitely stated that this is due to the system of changing over and final conclusions must await the 1932 measurements and yield figures; but from the interim results the experiment affords no support to the widely held opinion that changing over the cut results in better bark renewal.

The Rejuvenation Experiment

Allusion to this experiment has already been made (1) in an article entitled "Tapping to death: a Warning" which appeared in *The Tropical Agriculturist* for April, 1930, and (2) the progress report of this station for May and June, 1930.

In both publications stress was laid on the large number of cuts which had gone dry after a few months as a result, it is believed, of continuous daily tapping. The following table shows the situation at the end of a year of tapping:

	Number of trees	Total number of cuts put on	Number of cuts gone dry	Percentage of total number of cuts gone dry	Yield of dry rubber per tree for the year lb.	Yield of dry rubber per tree for the year oz.	Calculated yield of dry rubber per tree from previous year lb.	Calculated yield of dry rubber per tree from previous year oz.
Plot 1.—Tapped daily to the wood on two cuts on half circumference. Bark consumption 2 ins. per month, to be tapped for 1 year.	68	192	79	41	13	15	6	7
Plot 2.—Tapped daily to the wood on two cuts on the half circumference. Bark consumption $1\frac{3}{8}$ in. per month, to be tapped for 3 years.	76	206	69	33	14	7	8	8
Plot 3.—Tapped daily to the wood on two cuts on the half circumference. Bark consumption $1\frac{1}{1\frac{1}{2}}$ in. per month to be tapped for 3 years.	43	121	43	35	18	6	8	4
Plot 4.—Tapped daily in alternative days on two cuts on the half circumference. Fine tapping but not to the wood. To be tapped for 4 years.	40	82	2	2	14	8	8	7

The figures in the last column are based on Mr. Lord's computation made when the experiment was started, of the previous year's yield from 8 months' tapping on $\frac{1}{3}$ circumference. They are therefore empirical and only afford a rough comparison. It would appear that the yields obtained by intensive tapping are generally rather less than double the calculated of the previous year. It is to be noted that the yield of plot 4 is the second largest although it has received only half the number of tappings given to the other three plots. There are two possible explanations for the freedom from drying up of cuts and consequent comparatively high yield in plot 4.

(1) The fact that it is tapped daily in alternate months instead of continuous daily.

(2) The fact that it is not tapped to the wood.

101 trees in plot 13 were on a previous occasion tapped to the wood for a year. A general increase in yield of approximately 25% occurred and the incidence of brown bast was negligible. For this reason the writer is strongly of the opinion that the continuous daily tapping is the factor responsible for the drying up of cuts. It is intended to test this out in the experiment to be initiated next year in plots 151-154.

The tapping of plots 2, 3 and 4 is being continued, while most of the trees in plot 1 have been marked for eradication.

Brown Bast

A complete round of brown bast treatment was finished in August.

CACAO

In preparation for the cacao selection work outlined above a number of trees have been selected for yield recording and a nursery has been laid down to serve as stocks for future budding operations.

Helopeltis in cacao has been observed to be worse than usual.

A study of the viability of pollen from a barren tree and from a heavy yielding tree was completed in September by Mr. J. C. Haigh, Assistant Mycologist, whose report is given below.

"Germination tests have been carried out with pollen from a sterile cacao tree at the Experiment Station, Peradeniya. The tree bears abundant flowers but has never been known to set a pod. Comparative tests were carried out at the same time with pollen from a tree (No. 5. "B" cacao) that in the last three series of yearly records has produced respectively 119, 108 and 105 pods.

"The flower of *Theobroma cacao* opens in the early morning; advantage was taken of this fact to ensure that only fresh pollen was used for the tests. In the evening all opened flowers were removed from one branch of each of the trees under examination, thereby assuring that the flowers picked for experiment next morning were newly opened. The flowers were picked in the early morning and the pollen from them was sown on 1·5% agar in petri dishes. Five flowers were taken from each tree per day and the pollen from each anther was sown separately; twenty-five pollen masses per tree per day were thus obtained. Normal pollen germinates in a few hours in a moist atmosphere, but for convenience the pollen was examined twenty-four hours after sowing. Germinative power was judged by the percentage of pollen grains that had produced a germ tube. From the good tree 4,664 pollen grains were examined, of which 3,379, or 72·4%, had produced a germ tube in twenty-four hours; from the sterile tree 4,191 pollen grains were examined, of which only 15, or 0·36%, had germinated in the same length of time. Samples of pollen from the sterile tree were kept for five days, but no increase in germination percentage was observed. Pollen from the good tree was seen to germinate a few hours after sowing. The only observable difference between the pollen from the two trees was that that from the sterile tree contained a small percentage of larger, thin-walled grains. The normal pollen grain examined was about 20 microns in diameter and had a thick wall; the larger grains had a thin wall and were about 30 microns in diameter.

"The above tests show that the failure of the pollen of the sterile tree to germinate is a factor responsible for the sterility of the tree, since self-fertilisation is impossible. It is generally held that the cacao flower is in the main self-fertilised, but Harland has shown that cross-fertilisation occurs in cacao; it is still necessary, therefore, in accounting for the complete sterility of this tree, to explain the failure of cross-pollination. A detailed investigation will probably be necessary before this explanation is found; in the meantime a few simple hand pollinations have been made, using pollen from the good tree of the germination tests. It is perhaps of interest to note that similar tests carried out in the West Indies failed to show a significant difference in germinative power between pollen from good and poor yielders, and that in such trees, which were incidentally the progeny of the same parent, sterility was due to a defect in the female part of the flower."

COFFEE

The coffee year ended on September 30th. The following are the yields of fresh berries per bush for the last seven years:

Pounds fresh berries per bush

Robusta Types

Year	Robusta	Uganda	Quillou	Canephora	Hybrid
1923-24	2·37	3·43	6·91	3·01	8·38
1924-25	4·01	5·29	3·43	3·88	5·62
1925-26	3·23	2·06	3·91	3·09	9·78
1926-27	8·54	8·99	5·01	10·29	7·61
1927-28	5·57	6·86	13·45	7·63	8·26
1928-29	7·44	6·69	6·18	8·55	5·19
1929-30	7·58	7·82	5·94	8·38	7·82
Average	5·53	5·88	6·40	6·40	7·52

Liberian Types

Year	Excelsa	Abeokuta	Liberia Pasir Pogor	Klainii	Arnoldiana
1923-24	5·56	9·16	6·68	—	—
1924-25	19·82	12·84	13·34	—	—
1925-26	14·00	15·26	11·71	—	—
1926-27	25·80	18·94	21·21	—	—
1927-28	19·75	17·77	12·76	6·54	2·00
1928-29	22·00	31·20	27·16	2·54	2·50
1929-30	26·16	32·28	29·69	10·14	3·50
Average	19·01	19·63	17·51	6·40	2·66

Arabian Types

Year	Arabica (Plot 140 *1*)	Kent's	Jackson's Hybrid
1923-24	2·39	—	—
1924-25	2·39	·64	·18
1925-26	2·00	1·36	1·39
1926-27	3·26	·21	·58
1927-28	1·25	·69	·15
1928-29	1·93	1·84	·76
1929-30	1·20	·67	·63
Average	2·06	·89	·61

The yields of the Robusta types are well up to the average and a steady sale of seed and plants of these coffees continues. The yields of the Liberian types are high, but the berries contain a larger proportion of pulp and the produce fetches locally only about half the price of Robusta.

The yields of the Arabian types are as usual low and the bushes are in a very poor condition.

A round of pruning was completed early in September.

Considerable trouble has been experienced with red ants which abound in the coffee plots of the Economic Collection and have formed numerous nests. Spraying with kerosene emulsion, even at double the normal strength, proved ineffective.

Forty-eight bushes were selected for recording of individual yields.

FRUIT

A small amount of budwood was taken from the young grape fruit trees imported from South Africa in 1928, and the buds were put on to Pumelo stocks. The results were as follows:

Variety	Number of buds put on	Number of successes	Percentage
Cecily seedless	17	6	35·3
Ellen	28	10	35·7
Foster	30	17	56·6
Triumph	34	22	64·7
Marsh's seedless	37	27	72·9
Walters	30	20	66·6

The buds of Cecily seedless peeled badly and many were damaged. This is the first citrus budding done on the station and an improvement may be expected.

In addition budding was done from a number of sticks of budwood received from South Africa, but little success can be anticipated from this budding.

The regular spraying of citrus trees of value is to be undertaken under the supervision of the Mycologist as soon as supplies of "Sulfinette" arrive.

OIL BEARING TREES

The replacement of *Hydnocarpus whightiana* trees in block A of the terraced valley by *Taraktogenus kurzii* was carried out with the first north-east rains. All these plants are growing.

In block B 36 plants of *Aleurites montana* were put in to replace *Hydnocarpus whightiana* and 35 of these are growing well. This block was also extended and holes dug to receive additional plants of *Aleurites montana* when the seed of a mature tree near the store ripens.

The new arrangement of the area is as under:

Block A.	Taraktogenus kurzii (Chaulmoogra oil)	75 trees.
Block B.	Aleurites montana (Tung oil)	36 ,,
Block C.	Taraktogenus kurzii (Chaulmoogra oil)	177 ,,

Illuk was forked out of this area in October and the cheddy cut back from the edges of the terraces.

A system of paths and steps was also completed, giving easy access to all the terraces.

FIBRES

The sunn hemp trial under old coconuts and in the open mentioned in the last report was abandoned. In the former case germination was very poor and the plants all flowered at a height of about 2 feet. In the latter case germination was excellent but all the plants flowered at a height of 12 to 18 inches. The crop was ploughed in.

MISCELLANEOUS

All the sugar canes were dug out of the plots 18 D, 19 D and 20 D. Out of the nine varieties growing in those plots six have been replanted in the annual economic area. An order for sugar cane sets is a very rare occurrence.

A round of forking couch and illuk was completed by the end of October. This is the first round for which it has been possible to spare labour this year. It is feared that with the reduction in the labour force rendered necessary by the curtailment of the allocation this year the position in regard to these serious weeds is bound to deteriorate.

The following are the figures for revenue and expenditure (exclusive of monthly salaries) for the last seven years :

Year	Revenue Rs. Cts.	Expenditure Rs. Cts.
1923-24 ...	19,904·14 ...	31,400·81
1924-25 ...	33,546·44 ...	32,446·08
1925-26 ...	29,731·13 ...	33,091·59
1926-27 ...	33,775·61 ...	35,061·58
1927-28 ...	29,204·98 ...	37,820·95
1928-29 ...	24,284·77 ...	40,234·37
1929-30 ...	20,165·44 ...	40,998·73

The fall in revenue in the last two years is due to the decline in prices of the staple products, while the increase in expenditure is due to (1) increase in wages to bring these into conformity with the provisions of the Standard Wage Ordinance; (2) increase of the cultivated acreage of the station.

THE IRIYAGAMA DIVISION

The period under review has been one of great activity. All budding in the field in areas 1 and 2 and budding in the nursery for area 2 was completed. By the end of October most of the buds on the nursery plants had started to shoot and the stumps had been planted out in the field. Weather conditions were fortunately ideal—the north-east rains started just when the first buds started to shoot and good planting weather continued for some time.

Failures in areas 1 and 3 were rebudded on the other side of the stocks and a high percentage of successes was obtained from this rebudding. Final failures were replaced by reserve stumps budded for this purpose in the nursery. There are excellent prospects of getting a good even stand in these three areas. The full results of the above budding have been incorporated in an article for *The Tropical Agriculturist*. The article contains all percentages of successes and other figures which will therefore not be repeated here.

A further area, to be known as area 7, has been terraced and laid out for the reception of foreign clones. The area will contain plots of the following :

Ct 88
AVROS 256
P and T 11
P. B. 23
H 2
Seedlings

The necessary budding in connection with this area was done in the nursery in September and the plants will be put out when the buds shoot. Budded stumps of AVROS 256 are expected to arrive early in November.

In addition to this budding the budwood of certain mother trees which was insufficient to establish a clone of 60 trees this year was multiplied in the nursery.

There is a prospect of being able to establish another area of 10 clones next year, but after that no further mother trees are at present in sight and a good deal of opened land is likely to lie idle for a considerable time.

In addition to budding and connected operations the labour force has been employed in uprooting stumps and building stone steps.

T. H. HOLLAND,
Manager,
Experiment Station,
Peradeniya.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31st DECEMBER, 1930

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1930	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	1283	54	238	855	20	170
	Foot-and-mouth disease	264	2	254	10	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Colombo Municipality	Rinderpest	..	...	...	...	...	...
	Foot-and-mouth disease	448	1	434	12	1	1
	Anthrax	37	6	...	37	...	...
	Haemorrhagic Septicaemia	6	...	...	6	...	...
	Black Quarter	2	...	...	2	...	...
	Bovine Tuberculosis	1	...	...	1	...	...
	Rabies (Dogs)	12	1	...	...	...	12
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	..	...	...	...	...
	Anthrax (Sheep and Goats)	704 *	35	...	704	...	...
Central	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	660	10	658	2	...	...
	Anthrax (Sheep)	1	...	...	1	...	...
	Piroplasmosis	4	...	1	3	...	...
	Rabies (Dogs)	12	...	...	10	...	2
Southern	Rinderpest	351	29	86	261	4	...
	Foot-and-mouth disease	269	...	263	6	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	3	...	...	2	...	1
Northern	Rinderpest	4	...	3	1	...	...
	Foot-and-mouth disease	2975	...	2905	70	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	224	...	...	224	...	...
	Rabies (Dogs)	3	...	..	...	...	3
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	100	...	98	2	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	8195	1400	459	6782	13	941
	Foot-and-mouth disease	135	...	135	...	...	...
	Anthrax	...	...	...	...	...	...
	Pleuro-Pneumonia (in Goats)	50	...	...	50	...	...
North-Central	Rinderpest	1930	594	115	1681	24	110
	Foot-and-mouth disease	1069	...	1045	24	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	72	...	72	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	3	...	...	...	...	3
Sabaragamuwa	Rinderpest	63	...	7	54	...	2
	Foot-and-mouth disease	1445	...	1440	5	...	...
	Anthrax	..	...	...	...	...	...
	Haemorrhagic Septicaemia	85	16	...	85	...	...
	Rabies (Dogs)	14 †	...	...	4	...	10

* 1 case in a buffalo—Rest sheep and goats. † 1 case—a calf.

G. V. S. Office,
Colombo, 10th January, 1931.

G. W. STURGESS,
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METEOROLOGICAL REPORT

DECEMBER, 1930

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo -	86·8	+1·5	72·5	+0·6	70	90	5·0	0·27	3	- 5·17
Puttalam -	85·6	+1·8	70·6	+0·1	74	93	4·1	1·76	6	- 4·42
Mannar -	85·1	+2·6	75·5	+1·1	72	84	4·6	1·00	6	- 6·70
Jaffna -	83·5	+2·0	71·6	-1·4	74	95	5·4	0·98	6	- 9·33
Trincomalee -	81·6	+0·2	75·5	+1·4	77	84	4·8	2·22	9	-11·69
Batticaloa -	82·9	+1·2	73·0	+0·1	78	93	6·4	5·47	13	-11·08
Hambantota -	84·9	+0·5	72·3	-0·4	74	90	4·0	5·62	7	+ 0·28
Galle -	84·2	+1·0	73·3	+0·5	76	93	5·4	1·00	8	- 5·74
Ratnapura -	89·8	+3·7	71·8	-0·4	68	93	4·2	4·69	12	- 4·24
A'pura -	85·5	+2·7	68·2	-1·9	72	95	4·2	3·77	5	- 4·82
Kurunegala -	87·3	+1·6	70·9	+0·2	68	90	5·8	2·71	6	- 4·31
Kandy -	84·0	+2·7	66·8	-0·3	68	92	5·2	1·92	7	- 6·97
Badulla -	77·1	+0·6	63·5	-0·9	78	94	5·5	1·35	9	-10·88
Diyatalawa -	73·3	+2·1	57·0	-1·5	76	91	5·7	1·03	9	- 6·89
Hakgala -	69·3	+2·4	50·7	-2·1	80	87	4·5	1·41	11	-12·05
N'Eliya -	70·1	+3·9	44·6	-3·6	68	93	4·4	1·82	9	- 6·56

At about half the stations in Ceylon the total rainfall in December 1930, was lower than in the December of any previous year, while out of over 360 stations less than half a dozen recorded as much as their previous average. The biggest deficits were in the Rangalla district, where several were of the order of 30 inches.

Rain was particularly deficient during the week from the 15th-22nd, which coincided with the appearance of a mild depression in the Bay of Bengal, too far east to give rain in Ceylon. A depressional menace on the 23rd was responsible for six inches of rain at Topawewa on that day, but did not materialise further. The only other station to report over 5 inches in a day was Yataderiya with 7·70 inches on the 27th. The highest total was at Morawaka (19·86) which was the only station to record more than 15 inches. It is noteworthy that despite the general drought no stations failed to report any rain at all.

As the natural concomitant of the low rainfall the number of hours of bright sunshine was above average and the humidity and amount of cloud deficient. This latter resulted in the day temperatures being above average in all cases and the night ones being either below average, or less above average than the day temperatures were (Trincomalee alone was an exception to this). At Nuwara Eliya the night temperature in air got down to freezing point four times (19th-22nd) on which days the surface temperature went below 30°F.

Pressure was consistently high, and the direction of the gradient roughly from N.W. instead of the normal December direction which is from between N.N.W. and North.

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